GEORGIA INSTITUTE OF TECHNOLOGY | OFFICE OF CONTRACT ADMINISTRATION

PROJECT ADMINISTRATION DATA SHEET

[x] ORIGINAL
[ ] REVISION NO. ____

Project No. E-24-634 | DATE: 7/6/81

Project Director: Dr. Jerry Banks | School/Lab ISyE

Sponsor: Federal Emergency Management Agency; Acquisition Management Division; US
Washington, D.C. 20472

Type Agreement: Contract No. EMW-C-0655

Award Period: From 7/1/81 To ~~9/30~~ 12/31/82 (Performance) ---- (Reports)

Sponsor Amount: $49,853 | Contracted through:

Cost Sharing: None | GTRI/~~GIT~~

Title: Comparisons of Fire Loss Experience in the U. S. and Other Countries

ADMINISTRATIVE DATA | OCA CONTACT Duane Hutchison x4820

1) Sponsor Technical Contact: Mr. Henry Tovey, Project Officer; Federal Emergency Management Agency; Washington, D.C. 20472 202/634-7658

2) Sponsor Admin./Contractual Contact: Ms. Alice R.McKenzie, Contract Specialist; Federal Emergency Management Agency; Acquisition Management Division; Washington, D.C. 20472 202/634-7541

Reports: See Deliverable Schedule | Security Classification: none

Defense Priority Rating: none

RESTRICTIONS

See Attached government Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval - Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of $500 or 125% of approved proposal budget category.

Equipment: Title vests with government

COMMENTS:

COPIES TO:

Administrative Coordinator
Research Property Management
Accounting Office
Procurement/~~EES Supply Services~~
Research Security Services
~~Reports~~ Coordinator (OCA)
Legal Services (OCA)
Library, Technical Reports
EES Research Public Relations
Project File (OCA)
Other: ____

GEORGIA INSTITUTE OF TECHNOLOGY

OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION SHEET

Date 1/31/83

Project Title: Comparisons of Fire Loss Experience in the US and Other Countries

Project No: E-24-634

Project Director: Dr. Jerry Banks

Sponsor: Federal Emergency Management Agency; Acquisition Management Division

Effective Termination Date: 12/31/82

Clearance of Accounting Charges: 12/31/82

Grant/Contract Closeout Actions Remaining:

- [x] Final Invoice and Closing Documents
- [ ] Final Fiscal Report
- [x] Final Report of Inventions
- [x] Govt. Property Inventory & Related Certificate
- [ ] Classified Material Certificate
- [ ] Other ______

Assigned to: ISyE (School/~~Laboratory~~)

COPIES TO:

Administrative Coordinator
Research Property Management
Accounting
Procurement/EES Supply Services
Research Security Services
Reports Coordinator (OCA)
Legal Services (OCA)
Library
EES Public Relations (2)
Computer Input
Project File
Other ______

FORM OCA 10:781

E24-634

STATUS REPORT

COMPARISONS OF FIRE LOSS EXPERIENCE IN THE U.S. AND OTHER COUNTRIES

JULY-SEPTEMBER, 1981

EMW-C-0655

JERRY BANKS, PH.D.
PROJECT DIRECTOR
GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF INDUSTRIAL AND SYSTEMS ENGINEERING
ATLANTA, GEORGIA 30332

TASK ONE: Data Acquisition
During the First Quarter of the contract, requests for information were sent to previous respondents. The reports shown in Table 1 have been received as of the reporting date, September 30, 1981. However, numerous reports which are necessary to the completion of the selected international comparisons have not yet been received. The regular contributors from which no information has been received are shown in Table 2. Second requests for information have been sent to the primary respondents on Table 2 and a number of secondary sources have also been sent requests.

TASK TWO: Update of Selected International Comparisons
No activity scheduled for the report period.

TASK THREE: Fire Loss Verification
Completed "General Methodology for Hypothesis Testing Concerning Factors Affecting Fire Losses Using Data From Natural Experiments," a copy of which is attached.

TABLE 1
Reports on Hand as of September 30, 1981

	TITLE, MUNICIPALITY	YEARS
1.	Annual Report: Fire Losses in Canada	1978, 1979
2.	Annual Fire Loss Report, New Foundland and Labrador	1979
3.	Fire Report Annual, New Brunswick	1979
4.	Report of the Causes of Fire in Quebec	1979
5.	Intervention Des Sapeurs-Pompiers, France	1978-1979, 1980
6.	Fire Statistics, Switzerland	1979
7.	Fire Statistics, United Kingdom	1979
8.	Fire Statistics: United Kingdom: Supplement For Fire Brigades	1979
9.	Preliminary Report and Various Other Materials, Denmark	1979
10.	White Book on Fire Service in Japan	1980
11.	Fire in Berlin	1979, 1980

TABLE 2

Regular Contributors from Which Reports Have Not Been Received as of September 30, 1981

1. New South Wales
2. Austria
3. Belgium
4. German Casualty Insurance Association
5. Ireland*
6. Netherlands**
7. Norway
8. United States**
9. Tokyo, "Statistics on Fire Service in the World"***

*Promised
**Crucial to analysis of fires by cause and occupancy class
***Crucial to comparisons of city data

GENERAL METHODOLOGY FOR HYPOTHESIS TESTING CONCERNING FACTORS AFFECTING FIRE LOSSES USING DATA FROM NATURAL EXPERIMENTS.

INTRODUCTION

This research makes use of "natural" or quasi-experimental data. That is, data that exists in two or more natural environmental settings in which some factors are similar, but there are differences between other factors whose influence on fire losses we wish to examine. By analyzing the response variable (either fire death rate, incidents, or property damage), one may isolate or partially isolate the effect of certain factors on fire losses. The primary technique used in this research is regression analysis.

GENERAL DESCRIPTION OF METHODOLOGY

Suppose that y represents the response variable of interest, such as fire deaths, incidents, or property damage. We assume that data is available in at least two environmental settings that are similar in at least one important characteristic. For example, the two similar environmental settings might be Alaska and North Dakota. The similarity of these two environments is that both have persistent cold weather and are sparsely populated. Let $x_1, x_2, \cdots, x_{k-1}$ be a set of factors whose effect on fire losses we wish to investigate. Possible factors include population density, percent rural population, per capita income, per capita alcohol consumption, percent substandard housing, percent nonwhite population, and so forth. A significant part of each natural experiment is the identification of which factors to investigate.

A regression model relating the response y to each of the regression variables (the $x_1, x_2, \cdots, x_{k-1}$) is

$$y = \beta_0 + \sum_{j=1}^{k} \beta_j x_j + \varepsilon \tag{1}$$

where x_k is an indicator variable that categorizes the two environmental settings as follows:

$$x_k = \begin{cases} 0 \text{ if the observation is from North Dakota} \\ 1 \text{ if the observation is from Alaska} \end{cases}$$

Standard linear least squares methods may be used to fit this model, using yearly data from each location.

Note that the expected value of y for fixed values of all of the regressors in the two states is

$$E(y|x_1, x_2, \cdots, x_{k-1}, x_k = 0) = \beta_0 + \sum_{j=1}^{k-1} \beta_j x_j \quad \text{(North Dakota)}$$

$$E(y|x_1, x_2, \cdots, x_{k-1}, x_k = 1) = \beta_0 + \beta_k + \sum_{j=1}^{k-1} \beta_j x_j \quad \text{(Alaska)}$$

Thus the regression model in equation (1) actually describes two regression planes; one with intercept β_0 for North Dakota, and the other with intercept $\beta_0 + \beta_k$ for Alaska. The model assumes that the slope of the plane is the same in both states, that is the effect of x_1 given the other $x_2, x_3, \cdots, x_{k-1}$, as measured by the regression coefficient β_1, is the same for both states. The parameter β_k shifts the height of the regression plane, and represents a "state" effect on the response not captured by the other variables $x_1, x_2, \cdots, x_{k-1}$. To this extent it is the joint effect of all other unmodeled factors that are different in the two states and which significantly impact fire losses.

Statistical inference on all factors $x_1, x_2, \cdots, x_k$ is straightforward. For example, to test the contribution of any factor to the model we would test the hypothesis.

$$H_0: \beta_j = 0$$

$$H_1: \beta_j \neq 0$$

for $j = 1,2,\cdots,k$. This can be done using the standard partial F test or "extra sum of squares" method. The test on β_k is a test of the "state" effect; if this hypothesis is not rejected it implies that the two regression planes are coincident, that is, there is no difference between states. The least squares regression coefficient $\hat{\beta}_j$ is a point estimate of the effect of the variable x_j on fire losses (conditional on the other x's remaining constant) and a 100 $(1-\alpha)$ percent confidence interval on this effect is

$$\hat{\beta}_j \neq t_{\alpha/2,\, n-p} \text{ se } (\hat{\beta}_j)$$

where se $(\hat{\beta}_j)$ is the standard error of $\hat{\beta}_j$.

The assumption that the factors $x_1, x_2, \cdots, x_{k-1}$ have the same effects in each state may be unrealistic. To investigate whether these factors have state-dependent effects we may reformulate the model (1) as

$$y = \beta_0 + \sum_{j=1}^{k} \beta_j x_j + \sum_{j=1}^{k-1} \beta_{jk}\, x_j x_k + \varepsilon \tag{2}$$

For this model, the expected responses in the two states are

$$E(y|x_1, x_2, \cdots, x_{k-1}, x_k = 0) = \beta_0 + \sum_{j=1}^{k-1} \beta_j x_j \qquad \text{(North Dakota)}$$

$$E(y|x_1, x_2, \cdots, x_{k-1}, x_k = 1) = \beta_0 + \beta_k + \sum_{j=1}^{k-1} (\beta_j + \beta_{jk})\, x_j \qquad \text{(Alaska)}$$

Note that now β_k is a parameter that shifts the height of the regression plane between North Dakota and Alaska and β_{jk} is a parameter that allows the effects of x_j to vary between states also.

To test the hypothesis that factor x_j does not affect fire losses, we would test

$$H_0: \beta_j = \beta_{jk} = 0$$

$$H_1: \beta_j \text{ and/or } \beta_{jk} \neq 0$$

To test the hypothesis that the x_j effect is not location - dependent, test

$$H_0: \beta_{jk} = 0$$

$$H_1: \beta_{jk} \neq 0$$

Both hypothesis can be tested using the extra sum of squares method.

SOME SPECIFIC NATURAL EXPERIMENTS

1. Heating

It has been hypothesized that open-flame heating is an important factor in fire losses. To "block" out the effect of this factor so that other significant factors may be identified, it is necessary to find two regions that have significant amounts of open-flame heating. Suppose that two regions are the Northeast United States (perhaps Vermont) and Sweden.

Given that the levels of open-flame heating in these two sites is similar, other factors that would be worthy of investigation include population density (x_1), per capita income (x_2), percent rural population (x_3), percent minority population (x_4), percent wood construction (x_5), percent substantard housing (x_6), and the number of fire-fighting personnel /1000 of population (x_7). The initial regression model, following equation (1), is

$$y = \beta_0 + \sum_{j=1}^{8} \beta_j x_j + \varepsilon$$

where x_8 is the indicator variable that identifies the two sites.

The hypothesis H_0: $\beta_8 = 0$ may be interesting in this application. If this hypothesis is rejected, it implies that there are significant differences between the two sites, not explicitly incorporated in the other regressors presently in the model. Thus, if we conclude that $\beta_8 \neq 0$, we may wish to identify other factors for inclusion in the model, such as weather variables, education levels in the population, per capita tobacco/alcohol consumption, variables relating to the adequacy of the building codes, and so forth.

2. Cold Weather/Heating

The example cited earlier in which Alaska is matched with another state or region having persistent cold weather, such as North Dakota or Minnesota, can be used to block out the cold weather/heating effect which is often hypothesized to be influential in fire losses. Factors that could be investigated in this setting include those mentioned in the heating study above. Of particular interest in this experiment, however, are factors such as per capita alcohol consumption (Alaska has a relatively high proportion of alcoholics) and percent substandard housing (Alaska has a high percentage of mobile homes).

DATA REQUIREMENTS

To pursue any of these natural experiments, we must have data available from each site involved. Generally, these data must be yearly fire losses statistics, along with the corresponding information for population factors, alcohol/tobacco consumption, income, and so forth. A typical regression model of the form of equation (1) may contain from 5 to 10 regressors. If we wish to have 15-20 residual degrees of freedom, then 25 years of data must be available. In other words, yearly and data covering the period 1955-1980 would be required to perform many of the analyses of interest.

E24-634

STATUS REPORT

COMPARISONS OF FIRE LOSS EXPERIENCE IN THE U.S. AND OTHER COUNTRIES

OCTOBER-DECEMBER, 1981

EMW-C-0655

JERRY BANKS, PH.D.
PROJECT DIRECTOR
GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF INDUSTRIAL AND SYSTEMS ENGINEERING
ATLANTA, GEORGIA 30332

TASK ONE: Data Acquisition
As of the end of the Second Quarter of the contract, materials had been received from 12 nations. Attachment One contains a listing of the respondent(s) and the reference(s) material provided. However, there are several regular contributors from which no information has been received.

From the Tokyo Fire Department, "Statistics on Fire Service in the World," has been requested numerous times, to no avail. This report is crucial to the comparison of the cities section in the Update.

The Belgian report has not yet been received. It has been requested three times from one potential respondent, and two times from our alternative respondent. Data from the Belgian report is used in comparisons of aggregate fire indices.

Also, "Fire in the United States," is awaited. Normally, this is initially received in draft form from the NFDC, USFA. Receipt of this document is crucial to many segments of the Update.

TASK TWO: Update of Selected International Comparisons
The proposed outline for the Update has been submitted to NFDC, USFA.

TASK THREE: Fire Loss Verification
Completed "Determination of the Power of the Test for a Regression Model Involving a Natural Experiment." A copy is enclosed as Attachment Two. Completion of Task Three by the scheduled date will not be possible. An extension in time only has been discussed and verbally approved by the contract monitor. This extension will not effect the completion date of Task One and Two. The anticipated completion date of Task Three has been changed to May 31, 1982.

ATTACHMENT ONE

AUSTRIA

Respondent

Ing. J. Kaiser
Zentralstelle Für Brandverhütung
A-1030 Wien 3
Schwarzenbergplatz 7
AUSTRIA

Reference

"Die Brandschäden in Osterreich im Jahre 1980"

QUEBEC

CANADA

Respondent

Arthur Tasiaux
chef de Division
Service de la prévention
Government du Québec
Ministère des Affaires Muncipales
Direction Général de la Prévention des Incendies
20, Chauveau
Quebec
G1R 4Y6
CANADA

References

"Rapport des pertes causées par l'incendie au Quebec 1979(1980)"

"Definitions, etc."

"Vos Rapports D'Incendie Pourquoi Et Comment Les Rediger, 1976, 1977, 1978"

"L'incendie dans les municipalitiés du Quebec"

DENMARK

Respondent

Leif Bastiansen, Dep. Man.
Danish Insurance Information Office
Forsikringsoplysningen
10 Amaliegade
1256 Kobenhavn K
DENMARK

References

"Preliminary Report (1979)", Danish Insurance Supervision Service

"Table of Fire Claims (1978 and 1979)", Danish Statistical Department

"Articles from the Danish Insurance Review (Major Fires)"

"Press Release (Indemnities, 1980)"

CANADA

Respondent

G. A. Hope
Dominion Fire Commissioner
Public Works Canada
Immeuble Sir Charles Tupper Bldg.
Prom. Riverside Drive
Ottawa K1A OM2
CANADA

References

"Annual Report, Fire Losses in Canada, 1978(1979)"

"Study on Fire Prevention and Control Systems in Canada," pub. 1980

NEW BRUNSWICK

CANADA

Respondent

Ms. Joyce Parker
Fire Statistician
Office of the Fire Marshall
P.O. Box 6000
Frederickton, NB
E3b 5H1
CANADA

References

"Annual Fire Report (1979)"

"Fire Manual"

NEWFOUNDLAND AND LABRADOR

CANADA

Respondent

John N. Cardoulis, Fire Commissioner
Pleasantville Fire Station
Building 901
Pleasantville
St. John's Newfoundland
A1C 5T7
CANADA

Reference

"Annual Fire Loss Report, 1979"

NOVA SCOTIA

CANADA

Respondent

Richard Shephard
Office of the Fire Marshal
Department of Labour and Manpower
P.O. Box 697
Halifax, N.S.
B3J 2T8
CANADA

Reference

"Annual Report of the Fire Marshal for 1979 and for 1980"

FRANCE

Respondent

G. Rieutord
Ministere de L'Interieur et de la Decentralisation
Direction de la Securite Civile
Sous-Direction de la Prevention et des Etudes
Bureau de la Documentation, des Statistiques et de l'Informatique
1, Place Beauvau
75800-Paris
FRANCE

References

"Interventions des Sapeurs - Pompiers 1978-1979(1980)"

"Instructions Pour La Redaction"

GERMANY (WEST)

Respondents

Alfons Orth
dfv
Postfach 200269
D-5300 Bonn 2
WEST GERMANY

Seiden, Chief Fire Officer
Berliner Feuerwehr
Nikolaus-Grob-Web 2
1000 Berlin (West) 13
WEST GERMANY

Reference

"Jahresstatistik 1979(1980)", Berlin only

IRELAND

Respondents

Capt. C. I. Garvey
Chief Fire Officer
Cork Corporation Fire Dept.
Angelsea Street
Cork
IRELAND

Leo Connell
Department of the Environment
Custom House
Dublin, 1
IRELAND

Reference

"Fire Statistics 1979"

JAPAN

Respondent

Haruo Ohno, Chief Liason Branch
Tokyo Fire Department
3-5, Otemachi 1 Chome
Chiyoda Ku
Tokyo, 100
JAPAN

References

"White Book on Fire Service in Japan, 1980"

"Fire Service in Tokyo, 1980"

NETHERLANDS

Respondents

J. G. S. J. Van Maarseveen, Head
Department for Criminal and Judicial Statistics
Netherlands Central Bureau of Statistics
Prinses Beatrixlaan 428, Postbus 959
2270 AZ Voorburg
THE NETHERLANDS

B. M. Van Der Harst, Librarian
Department for Criminal and Judicial Statistics
Netherlands Central Bureau of Statistics
Prinses Beatrixlaan 428, Postbus 959
2270 AZ Voorburg
THE NETHERLANDS

Dr. Evert C. Wessels
TBBS
EEMNESSERWEG 56
3740 ab Baarn
Postbus 54
THE NETHERLANDS

References

"Statistek der Branden 1978"

"Statistek der Branden 1979"

"Provisional Figures 1980"

"Miscellaneous 1980"

"Classification List"

NEW SOUTH WALES

AUSTRALIA

Respondent

Mr. J. J. Keough, Manager
Fire Research
Department of Construction
Experimental Building Station
87-101 Delhi Road
North Ryde, N.S.W.
AUSTRALIA

Reference

"Fire Statistics: New South Wales: 1979"

NEW ZEALAND

Respondent

Denis Bastings, Head
Fire Research Division
Building Research Association of New Zealand
Private Bag
Porirua
NEW ZEALAND

References

"Report of the New Zealand Fire Service Commision 1978, 1979, 1980"

NORWAY

Respondent

A. Rydning
Norges Brannkasse
Postboks 1045 Sentrum
OSLO 1
NORWAY

Reference

"Branher i Norge 1978(1979"

SWITZERLAND

Respondent

Dr. W. Lindenmann
BVD-SPI
Nüschelerstrasse 45
CH-8001
Zürich
SWITZERLAND

Reference

"Brandstatistik 1979"

ATTACHMENT TWO

DETERMINATION OF THE POWER OF THE TEST FOR A REGRESSION MODEL INVOLVING A NATURAL EXPERIMENT

All of the natural experiments considerd in this research involve fitting a linear regression model to a set of observed data. The data have been selected and the model formulated so that a research question of interest can be investigated by testing whether or not a particular regression coefficient equals zero. In deciding <u>which</u> set of natural experiments to run, the experimenter would like to assess the likelihood that the experiment will be successful. This is important because of the cost associated with data collection. A natural way to do this is through the <u>power of the test</u>; that is, the probability that the hypothesis $H_0: \beta_j = 0$ will be rejected <u>given</u> that β_j is really not equal to zero. On other words the power is the probability of correctly reporting a significant finding.

All of the regression models used in this research can be written in general terms as

$$\underline{y} = \underline{X}\underline{\beta} + \underline{\varepsilon}$$

where $\underline{y}$ is an n×1 vector of observations on fire losses incidents, or deaths, $\underline{X}$ is an n×p matrix of the independent variables, $\underline{\beta}$ is a p×1 vector or regression coefficients, and $\underline{\varepsilon}$ is an n×1 vector of random errors. The least squares estimator of $\underline{\beta}$ is

$$\hat{\underline{\beta}} = (\underline{X}'\underline{X})^{-1} \underline{X}'\underline{y}$$

we wish to test the hypothesis that one regression coefficient, say β_1, equals zero. That is,

$$H_0: \beta_1 = 0$$

$$H_1: \beta_1 \neq 0$$

It is convenient to write the regression model as

$$y = \underline{X}_1\underline{\beta}_1 + \underline{X}_2\underline{\beta}_2 + \underline{\varepsilon}$$

where X_1 is an n 1 vector consisting of the levels of the regressor $\underline{X}_1$, and $\underline{X}_2$ is an n×(p-1) matrix representing the remaining columns of the original $\underline{X}$ matrix. The $\underline{\beta}$ vector is conformably partitioned into $\underline{\beta}' = [\beta_1, \underline{\beta}_2']$, where $\underline{\beta}_2$ is (p-1)×1.

We now assume that the $\underline{X}$ matrix and $\underline{y}$ vector are scaled to <u>unit length</u> form. This implies that $\underline{X}'\underline{X}$ and $\underline{X}'\underline{y}$ are in correlation form. Specifically, the sum of squares of any column in $\underline{X}$ is unity. Furthermore, the β's are usually called standardized regression coefficients.

Now it is well-known that the power of the partial F-statistic used for testing H_0: $\beta_1=0$ can be evaluated from the noncentral F distribution. Specifically, the general distribution of

$$F_0 = \frac{SS_R(\beta_1|\beta_0,\beta_2,\ldots,\beta_k)}{MS_E} \tag{1}$$

is noncentral F with 1 and n-p degrees of freedom and noncentrality parameter

$$\lambda = \frac{\beta_1^2 B}{2\sigma^2}$$

where $B = \underline{X}_1'\underline{X}_1 - \underline{X}_1'\underline{X}_2(\underline{X}_2'\underline{X}_2)^{-1}\underline{X}_2'\underline{X}_1$. In equation (1), $SS_r(\beta_1|\beta_0,\beta_2,\ldots,\beta_k)$ is the extra sum of squares associated with the hypothesis H_0: $\beta_1=0$ and MS_E is the usual residual mean square.

One way that the power may be determined in practice is by using talks prepared by P.C. Tang (see Graybill (1961) for an excellent general description of the procedure]. Tang's tables are prepared in terms of the numerator (f_1)

and denominator (f_2) degrees of freedom on F and a fraction of λ, namely

$$\phi = \sqrt{2\lambda/(f_1+1)}. \tag{2}$$

For our problem, (2) becomes

$$\phi = \sqrt{2(\beta_1^2 B/2\sigma^2)/(f_1+1)} = \frac{\beta_1}{\sigma}\sqrt{\frac{B}{2}} \tag{3}$$

since $f_1=1$. Note that β_1/σ can be interpreted as the <u>signal-to-noise ratio</u>; that is, how big is the effect we are looking for in <u>standard deviation units</u>. Furthermore, since B is always positive definite, we know that $0 < B \leq 1$. Thus a maximum value for ϕ is

$$\phi_{max} = \frac{\beta_1}{\sigma}\frac{1}{\sqrt{2}}$$

for any particular signal-to-noise ratio. Since the minimum value of B exceeds zero by some ε, an approximate average value for ϕ is

$$\phi_A = \frac{\beta_1}{\sigma}\frac{1}{2\sqrt{2}} \tag{4}$$

Now the choice of ϕ directly affects the power, since in any experiment n and p are fixed. Thus we need only choose the ratio β_1/σ to determine the power. A small choice of β_1/σ implies a small effect, one that will be difficult to detect, while a large choice of β_1/σ implies a large effect, one that will be easy to detect. Values of ϕ_A in the range $1 \leq \phi_A \leq 2.5$ correspond to small values of β_1/σ, while values in the range $2.5 \leq \phi_A \leq 8$ correspond to larger values of β_1/σ. Note that Tang's tables give the type II error probability, so that the power of the test is one minus the values in the body of the table.

E-24-634

E24-634

STATUS REPORT

COMPARISONS OF FIRE LOSS EXPERIENCE IN THE U.S. AND OTHER COUNTRIES

JANUARY - MARCH, 1982

EMW-C-0655

JERRY BANKS, PH.D.
PROJECT DIRECTOR
GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF INDUSTRIAL AND SYSTEMS ENGINEERING
ATLANTA, GEORGIA 30332

TASK ONE: Data Acquisition

Completed with the major portion of the data base exhibited to Mr. Henry Tovey, USFA, during site visit on January 25, 1982.

TASK TWO: Update of Selected International Comparisons

Format approved by USFA. The sections of the document are in the following stages of completion:

Executive Summary		0% Complete
Chapter 1. Introduction	Draft	90% Complete
Chapter 2. Comparison of Aggregate Fire Indices	Draft	95% Complete
Chapter 3. Comparison by Occupancy and Cause	Draft	90% Complete
Chapter 4. Fatality Patterns	Draft	60% Complete
Chapter 5. Comparisons of City Data	Draft	100% Complete
References		0% Complete
Appendix A. Supporting Tables	Typing	100% Complete
Appendix B-1 Derivation of Values in Table 2-1	Typing	80% Complete
Appendix B-2 Computation of Technological Index in Table 2-2	Draft	100% Complete

STATUS REPORT

Appendix B-3 Derivation of Values in Table 3-1	Typing	80% Complete
Appendix B-4 Derivation of Values in Table 3-2 through 3-5	Draft Typing	80% Complete 60% Complete
Appendix C Sources of Information	Typing	90% Complete

Summary of Task Two: The task is tracking the scheduled dates of completion very closely. It is anticipated that the completed comparisons document and executive summary will be delivered to USFA for comment, by July 31, 1982.

TASK THREE: Fire Loss Verification

No activity during this quarter.

E24-634

STATUS REPORT

COMPARISONS OF FIRE LOSS EXPERIENCE IN THE U.S. AND OTHER COUNTRIES

APRIL - JUNE, 1982

EMW-C-0655

JERRY BANKS, PH.D.
PROJECT DIRECTOR
GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF INDUSTRIAL AND SYSTEMS ENGINEERING
ATLANTA, GEORGIA 30332

TASK ONE: Data Acquisition

Completed during an earlier reporting period.

TASK TWO: Update of Selected International Comparisons

Three draft copies were presented to Henry Tovey on June 11, 1982. On that date, a seminar was given for 25-30 interested persons. Attendees were mostly from FEMA, but there were also representatives from the Bureau of Standards, the Consumer Product Safety Commission, and the National Fire Protection Association.

Copies of the document are being submitted to reviewers. Comments should be received by July 23, 1982.

TASK THREE: Fire Loss Verification

Rough data for three natural experiments was obtained. Regression models were built. The outputs have indicated that a large portion of the variation can be explained. The explanation of the experiments, analysis of the outputs, suggestions for a future research agenda, and conclusions must now be prepared.

SELECTED INTERNATIONAL COMPARISONS OF FIRE LOSS

1979–1980

By

Jerry Banks

GEORGIA INSTITUTE OF TECHNOLOGY

Atlanta, Georgia 30332

With the Support of the
Federal Emergency Management Agency
Grant No. EMW–6–0655

September 1982

EXECUTIVE SUMMARY

The consistent finding of comparative estimates of fire loss experience in various developed nation's has been that the United States has one of the highest rates of per capita fire incidence and fire fatality. These comparative estimates have been published intermittently for a number of years. Statistics from Australia, New Zealand, Canada, Japan and several western European nations are compared to those of the United States for the 1979-80 and earlier time periods.

Any comparison between reported fire losses of different countries is beset by major incomparabilities in the data and the procedures by which the statistics are calculated. When, as in the case of this report, published results from individual countries are interpolated to conform to a standard format, additional opportunities for confusion are introduced. Thus, the reader should treat all conclusions from the data presented only as indications of possible phenomena. Within these limitations, however, some conclusions do seem appropriate.

- <u>Building Fire Incidence</u>. The incidence of building fires per 1,000 persons was estimated for seventeen nations including the United States. Although the United States exhibited the fourth largest rate of decrease over the last two time periods, its per capita rate of reported building fires was second highest of the countries reported. The United States rate for 1979-80 is approximately one and one-half times that of our neighbor Canada.

- <u>Building Fire Loss</u>. The United States rate for monetary building fire loss ranks the United States in the middle of

world cities considered. Relatively higher fire incidence in the United States is reflected by the greater numbers of fire personnel employed.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

The consistent finding of international comparisons has been that the United States has one of the highest rates for per capita fire incidence and fire fatalities among the developed nations of the Western World [5, 22]. As a first systematic effort to obtain some understanding of what causes such differences in reported fire loss, the Federal Emergency Management Agency sponsored the Georgia Insitute of Technology in a grant project entitled, Determinants of International Differences in Reported Fire Loss. The object of the project was to systematically enumerate and screen the various hypotheses and theories which have been advanced to explain fire loss differences among nations - including social, economic, cultural, technological and fire policy variations, as well as differences in statistical reporting procedures. The principal results of this Georgia Tech project are a Final Technical Report [26] and a Final Summary Report [25] both published in 1977.

As an extension of the earlier work, the Georgia Tech research team undertook in 1978 to produce two additional reports. The first of these, entitled Report on Fire Data Collection and Presentation [27], more thoroughly analyzed the collection and analysis systems used to prepare fire data in different countries. The second supplemental report, Selected International Comparisons of Fire Losses, [28] provided detailed analyses of fire loss in a limited set of countries, based on fire statistics for 1973-75. An updated version of this report, entitled Selected International Comparisons of Fire Losses, 1975-78 [2], was published in 1980. A second update of [28] is presented here. It extends the earlier analyses through the 1979-80 time period, and the results of the three time periods are compared for trends or changes in the relative position of the United States.

Several specific analyses are included. In Section 2, aggregate indices of fire loss are compared for the United States, Australia, New Zealand, Canada, Japan and twelve European nations. The incidence of building fires, losses resulting from building fires, and rates of fire fatalities are related to a nations population, and its economic activity. Section 3 contains more detailed comparisons by the occupancy of the fire site and the cause of the fire. The United States, the United Kingdom, the Netherlands and Australia are represented. Rates of fire incidence are calculated for particular classes of residential, non-residential, mobile and outside property; residential and non-residential are further subdivided by cause. Section 4 focuses on fire fatalities. Drawing on World Health Organization reports of deaths due to fire and flame accidents [39], age and sex differences in fire fatalities are analyzed for seventeen developed nations including the United States. A final section presents fire loss data from major cities of the world. Using reports collected by the Tokyo Fire Department [32] from 48 foreign and U.S. cities, populations, numbers of fires, fire deaths, and number of fire personnel are correlated.

Any extensive comparison between reported fire losses of different countries is beset by major incomparabilities in the data on which statistics are based and the procedures by which the statistics are calculated. Reporting differences at the point of occurence can have a major impact on the reported fire losses of a nation. For example, in nations where calling the fire service is emphasized, regardless of the severity of the fire, the number of reported incidents may be much higher than in nations where having a fire is considered a form of criminal act. Also, in nations where reporting of fires is a lengthy process on the part of the fire service, there may be a tendency to omit reporting of minor incidents. In other nations it may be possible to report minor incidents in an abbreviated form, decreasing the likelihood of omission. As a last example, fire losses in some nations are determined by the fire service, while in other nations they are based on insurance claim payments. When published results may be manipulated and interpolated to conform to a standard format, additional opportunities for confusion are introduced. Still, useful insights and directions for future research do arise from such rough investigations. The reader should accept none of the results to follow as irrefutable, but instead, should view them as indications of underlying phenomena.

1.1 Sources of Information

As detailed in Appendix C[1] the Georgia Tech research team has undertaken a rather thorough effort to contact and obtain reports from agencies known to be producing fire loss statistics in various industrialized nations. Although only a few sources were discovered that analyze fire loss in as much detail as FEMA National Estimates, information that could be used in one or more of the tables and figures in this document was obtained for a variety of countries. Specific sources of national data are detailed in Table 1-1.

---

[1]All Appendices are contained in "Selected International Comparisons of Fire Loss: 1979-1980: Appendix," which is available, on request, from the Federal Emergency Management Agency, Washington, D.C., 20472.

TABLE 1-1

SOURCES OF NATIONAL FIRE STATISTICS

COUNTRY	SOURCE OF INFORMATION
Australia	Fire Statistics, New South Wales, 1979 [4], which contains statistics of service calls made by the New South Wales Fire Brigade to fires and other hazards. "As New South Wales is fairly representative of Australia generally, it is reasonable to use the population ratio as a factor to obtain a national picture" [19].
Austria	Reports for 1979 and 1980 of The Austrian Fire Prevention Agency [10]. The report is derived from a combination of official fire reports and insurance sources.
Belgium	Summary of 1979 and 1980 Belgian Fire Brigade operations [3] produced by the Belgian Ministry of the Interior.
Canada	Report for 1979 of the Dominion Fire Commissioner [11] which is compiled from data provided by the provincial fire marshals and fire commissioners, the fire marshals of the Territories, the Canadian Forces Fire Marshal and Statistics Canada.
Denmark	Reports of fire losses for 1978-79 were prepared by Danmarks Statistik [9], based on information from insurance companies.
France	Reports for 1978-79 and 1980 of the French Fire Department [14]. The reports are published by the Ministry of the Interior, Department of Public Safety for Civil Security - Bureau of Documents, Statistics and Information. Reports of the Assemblée Plénière des Sociétés d' Assurances based on fire claims in France for 1979 and 1980 [1].
Germany (F.R.)	Summary Report of insurance claims provided by Verband der Sachversicherer (Vds) [8].
Ireland	Values for 1979 compiled by the Irish Department of the Environment [17]. Statistics are based on local authority reports.
Japan	White Book on Fire Service in Japan for 1980 [18], by the Japanese Fire Defense Agency, which is derived from reports of responses by Japanese fire brigades.
Netherlands	Reports for 1979 of the Centraal Bureau voor de Statistiek in the Dutch government [12], which is derived primarily from reports on responses of Dutch fire brigades.

TABLE 1-1 (Continued)

SOURCES OF NATIONAL FIRE STATISTICS

COUNTRY	SOURCE OF INFORMATION
New Zealand	Summary report for 1978-80 of the New Zealand Fire Service Commission [23]. The report is compiled from fire district reports.
Norway	Publications for 1978 and 1979 [24], describing the distribution of fires by sources and causes, based on reports from all fire insurance companies underwriting in Norway.
Sweden	Figures for 1980 published by the Swedish Fire Protection Association [30].
Switzerland	Values for 1979 published by the Association of Public Insurers of Switzerland [31].
United Kingdom	Reports of the British Home Office for 1979 [6], the statistics presented are of fires attended by local fire brigades. Monetary loss values come from the British Insurance Association [7].
United States	FEMA's <u>Fire in the United States</u> for 1979 and 1980 [21], which is derived from the surveys conducted by the National Fire Protection Association, data from the National Center for Health Statistics, and from reports on fire department responses entered in the NFIRS information system.

In addition to the sources listed in Table 1-1, information for individual cities was obtained from a report by the Tokyo Fire Department [32]. This report is based on 1980 data which was collected by the Tokyo Fire Department through surveys of numerous fire departments around the world.

In preparing the exhibits which follow, it was often necessary to perform interpretations and interpolations of the source data. The purpose of such actions was to reconcile subdivisions by cause and occupancy, and to convert foreign losses to United States dollars for a base year, in order to have all data correspond more directly with each other and with FEMA's national estimates. Although values were not presented unless a reasonable basis for interpretation or interpolation could be developed, some decisions were necessarily arbitrary.

Furthermore, all decisions were based on the very limited information available within reports on the definitions of categories for which national statistics were reported. Details of calculations performed are provided in Appendix B.

2. COMPARISONS OF AGGREGATE FIRE INDICES

2.1 Fire Indices

Fire statistics published by various national agencies provide numbers of fire incidents, numbers of injuries due to fires, number of fire fatalities, and estimates of direct monetary loss from fires. Specific reports may contain one or more of these measures. Prior Georgia Tech analysis in the Final Technical Report [26] showed that the number of fatalities and the amount of monetary loss attributed to non-building fires is small, and that there is high variability among nations in the degree to which non-building fires are included in reports. For that reason, in preparing aggregate fire loss comparisons, only building fires are included in incidence and monetary loss analyses. Some nations do report injuries, but the definiton and comparability of these reports is very doubtful. For this reason, injuries are not compared in this report.

The single instance in which fire data is systematically collected by an international agency is the fire fatality information published by the World Health Organization (WHO). Figure 2-1 compares death rates available from individual national reports to those WHO statistics. As seen in the figure, the WHO values are usually smaller. WHO statistics are derived from cause of death data on death certificates. Disparities between them and fire service reports derive mainly from differences in handling of incidents that might or might not be called a fire death. For example, WHO classifies deaths due to fires connected with motor vehicle collisions as automobile accident deaths, not as fire deaths. As another example, a burn victim may die of pneumonia after a long hospitalization. The death certificate may not attribute the death to

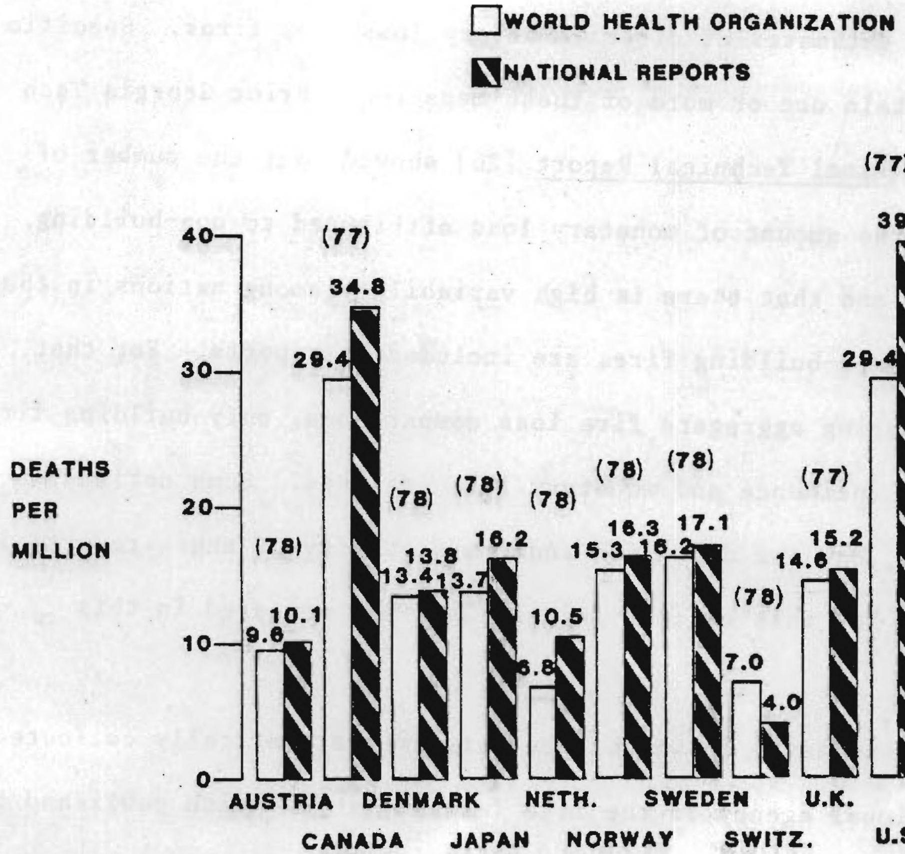

FIGURE 2-1. COMPARISON OF WORLD HEALTH ORGANIZATION AND NATIONAL REPORT FIRE DEATH RATES

Note: Year of comparison indicated in parentheses.

fire. Nevertheless, WHO values appear to present the most consistent basis for comparison among a wide group of nations. For this reason, all national death statistics to follow are derived from WHO values. Like fire incidents, monetary fire loss estimates in this report are adjusted to reflect only building fires. However, additional adjustments are necessary to convert monetary values into a single currency for a specific year. As detailed more completely in Appendix B, monetary loss estimates for the latest time period (1979-80) were obtained by adjusting to a standard year (1979) through consumer price indices of the United Nations Statistical Office [35] and the prevailing exchange rates published by the International Monetary Fund [16].

By whatever method fire loss is measured, it is not possible to make meaningful comparisons among nations unless loss values are standarized into indices. The most widespread approach for producing loss indices from monetary loss estimates, fire counts, and numbers of fire deaths is the calculation of per capita rates. However, per capita rates are not the only reasonable choice. Other possibiilities are comparison to the size of economies as measured by the Gross National Product, and computation of losses per fire incident.

2.2 Comparisons

Table 2-1 presents all such indices for Australia, Canada, Japan, New Zealand, the United States and twelve western European nations. Figure 2-2 compares results in Table 2-1 to similar ones for 1965-67, 1972-74 and 1976-78. (See Appendices Tables A-2, A-3, and A-4 for details of the earlier time periods.) Major highlights of Table 2-1 and Figure 2-2 are the following:

TABLE 2-1

COMPARISONS OF FIRE LOSS INDICES

COUNTRIES	Building Fires/1,000 Persons	$ Building Fire Loss Per Capita	Building Fire Loss As % of GNP	Fire Deaths/ 1,000,000 Persons	Building Fire Loss/ Fire ($1,000's)	Fire Deaths/ 1,000 Building Fire
Australia	1.2	-	-	11.5	-	9.2
	26%	-	-	39%	-	144%
Austria	2.6	18.3	.165	9.6	7.0	3.7
	56%	88%	85%	33%	155%	58%
Belgium	1.7	-	-	12.5	-	7.3
	37%	-	-	42%	-	114%
Canada	2.9	27.7	.28	29.4	9.6	10.2
	63%	132%	144%	100%	213%	159%
Denmark	3.1	39.6	.30	13.4	12.9	4.4
	67%	189%	154%	46%	287%	69%
Finland	-	-	-	17.3	-	-
	-	-	-	59%	-	-
France	1.7	30.8	.285	14.5	18.2	8.6
	37%	147%	146%	49%	404%	134%
Germany	-	21.7	.17	8.6	-	-
	-	104%	87%	29%	-	-
Ireland	7.6	14.8	.53	-	1.9	-
	165%	71%	272%	-	42%	-
Japan	0.3	5.2	.06	13.7	15.6	40.8
	6%	25%	31%	47%	347%	637%
Netherlands	0.9	22.8	.21	6.8	25.3	7.5
	20%	109%	108%	23%	562%	117%
New Zealand	3.3	-	-	12.8	-	3.9
	72%	-	-	43%	-	61%
Norway	4.4	38.3	.325	15.3	8.6	3.4
	96%	183%	167%	52%	191%	53%
Sweden	-	-	-	16.2	-	-
	-	-	-	55%	-	-
Switzerland	1.8	12.0	.07	7.0	6.6	3.8
	39%	57%	36%	24%	147%	59%
United Kingdom	2.1	14.5	.235	14.6	6.9	7.0
	46%	69%	120%	50%	153%	109%
United States	4.6	20.9	.195	29.4	4.5	6.4
	100%	100%	100%	100%	100%	100%

Notes: Losses are expressed in 1979 U.S. dollars.

Population data are from the Statistical Yearbook [36] and are usually 1976 or 1977 estimates.

Death values are from WHO Statistical Annual: Vital Statistics and Causes of Death [39] for the latest year available (usually, 1977 or 1978).

(Notes continued on next page.)

GNP values are for the year or years of the associated loss. If losses are reported for both 1979 and 1980, the measure associated with the loss is an average value for the two years.

Percentages reflect the ratio formed by comparing the fire loss index value for the country under consideration to the same fire loss index value for the United States. For example, Building Fires/1,000 Persons for Australia is (1.2/4.6) x 100% = 26% of that same measure for the United States.

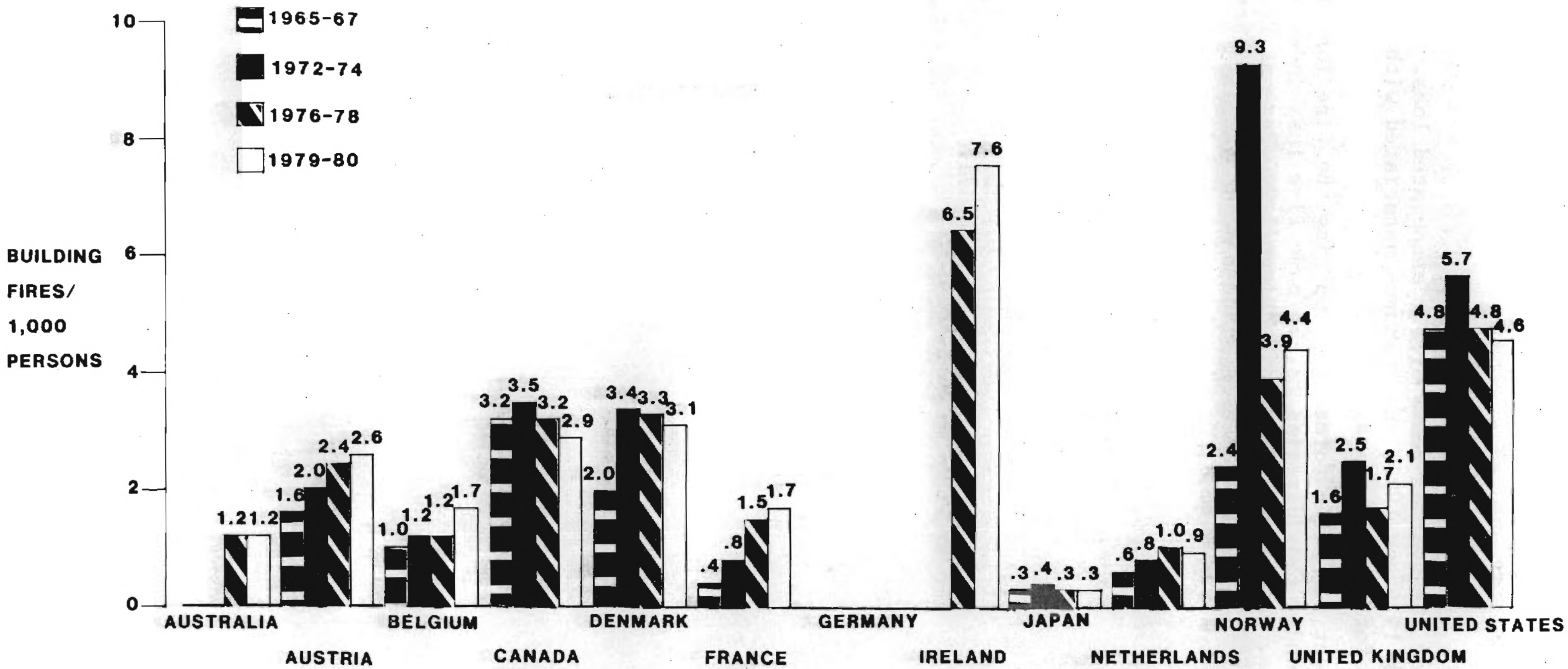

FIGURE 2-2. COMPARISON OF FIRE LOSS INDICES

Notes: Values for current time period are taken from Table 2-1 of the document. Values for earlier time periods, other than death data, are taken from earlier Georgia Tech reports [2, 28].

Death values are from WHO Statistics Annual: Vital Statistics and Causes of Death [29] and reflect an average for the time period indicated.

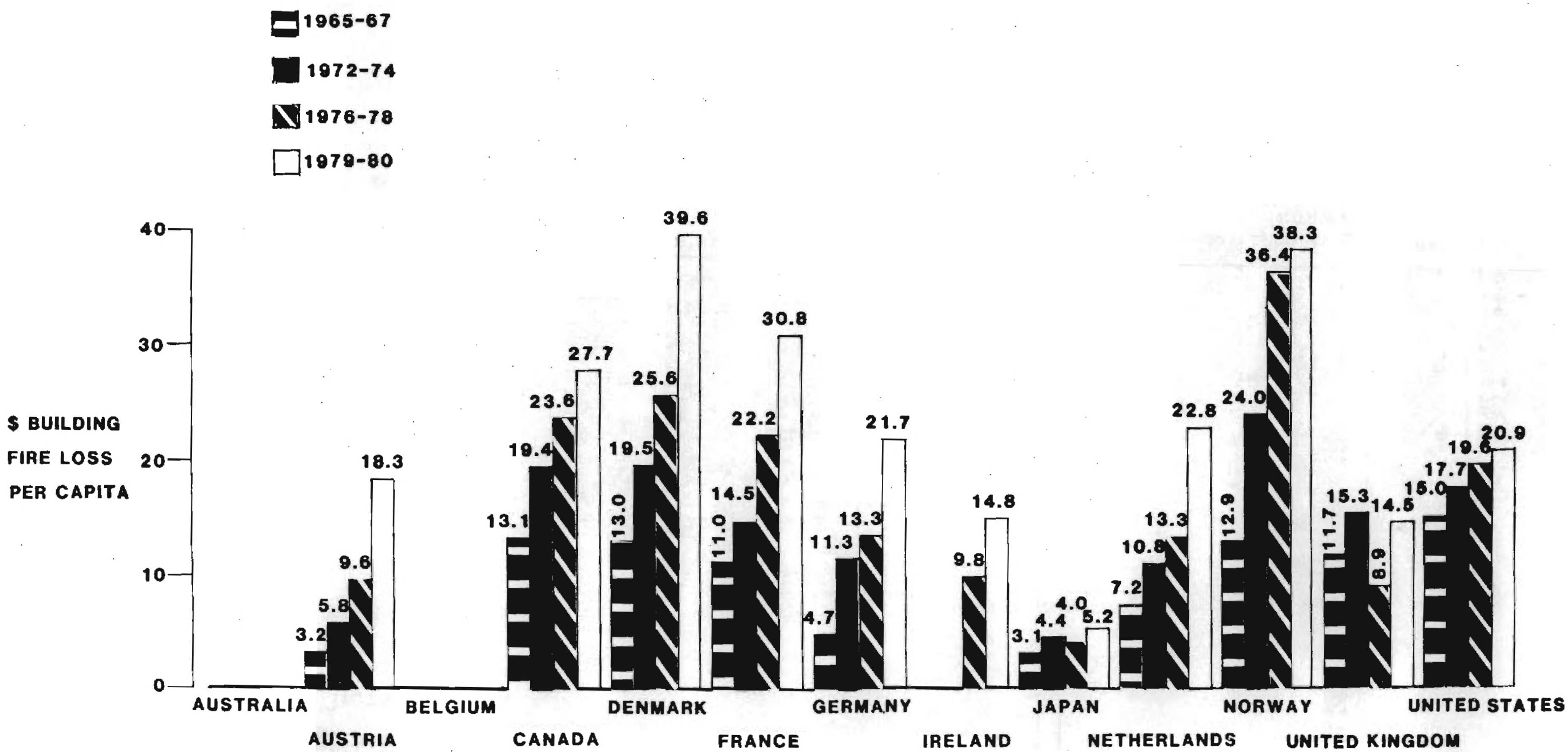

FIGURE 2-2 (CONTINUED). COMPARISONS OF FIRE LOSS INDICES

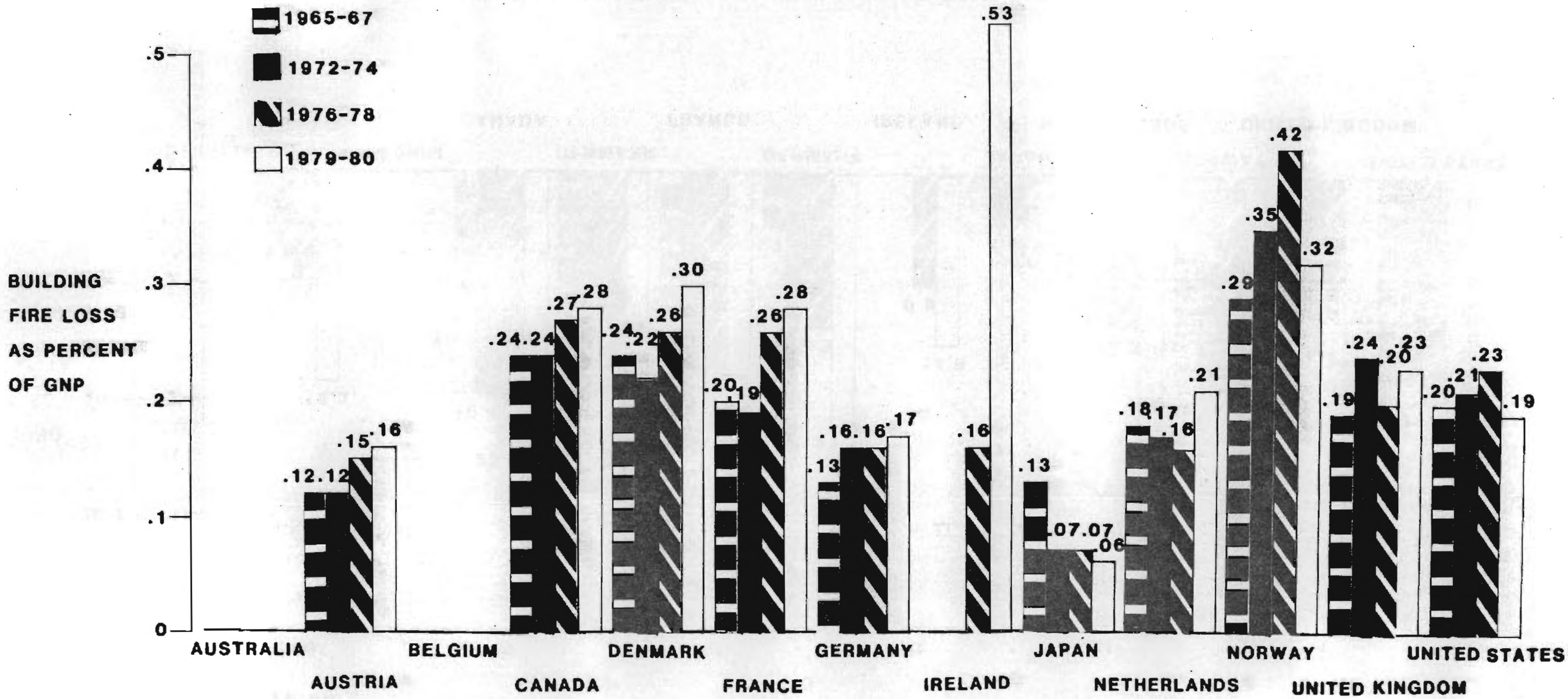

FIGURE 2-2 (CONTINUED). COMPARISONS OF FIRE LOSS INDICES

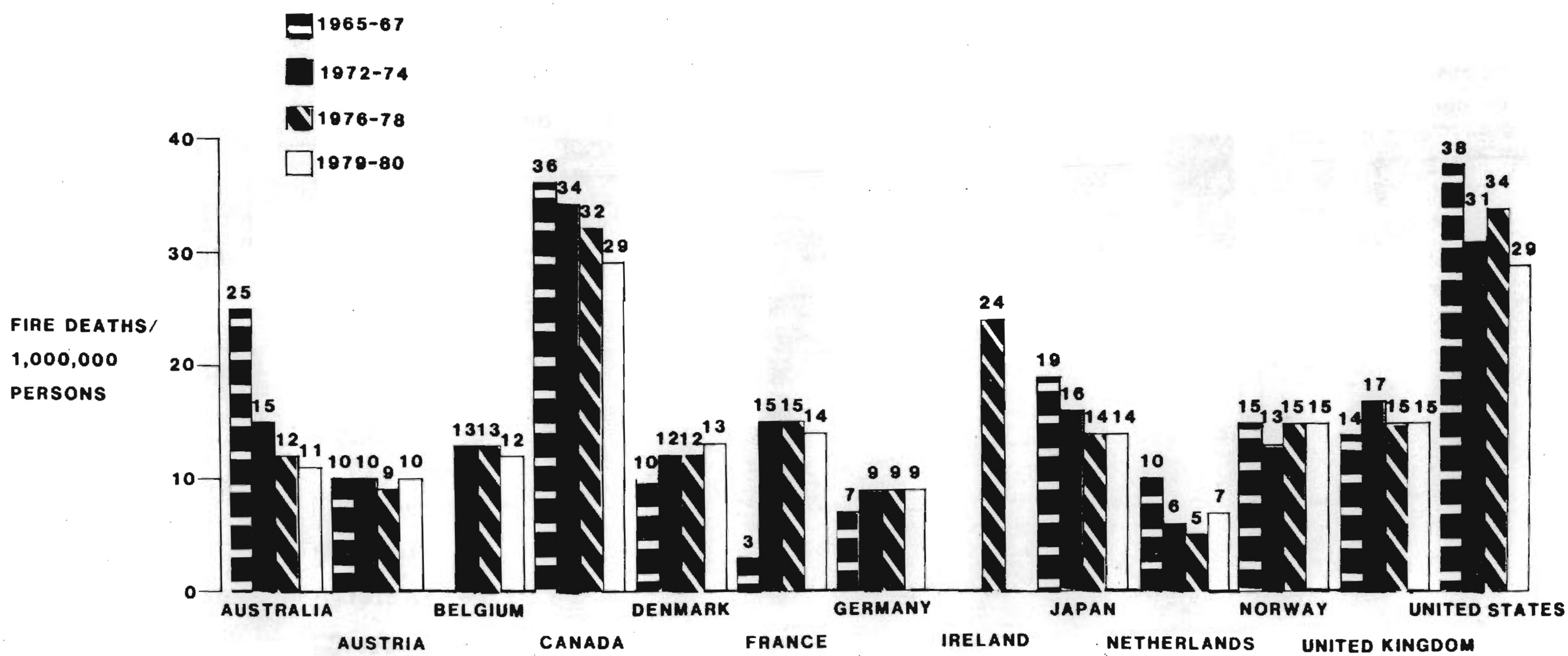

FIGURE 2-2 (CONTINUED). COMPARISONS OF FIRE LOSS INDICES

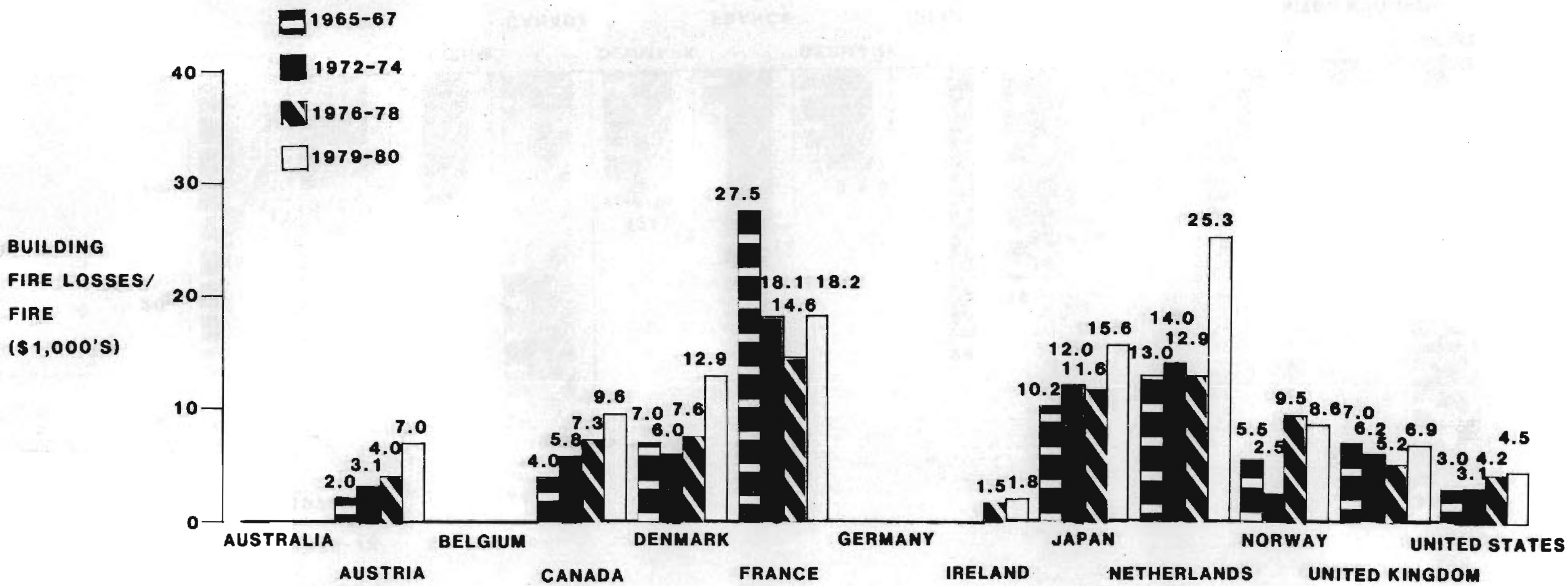

FIGURE 2-2 (CONTINUED). COMPARISONS OF FIRE LOSS INDICES

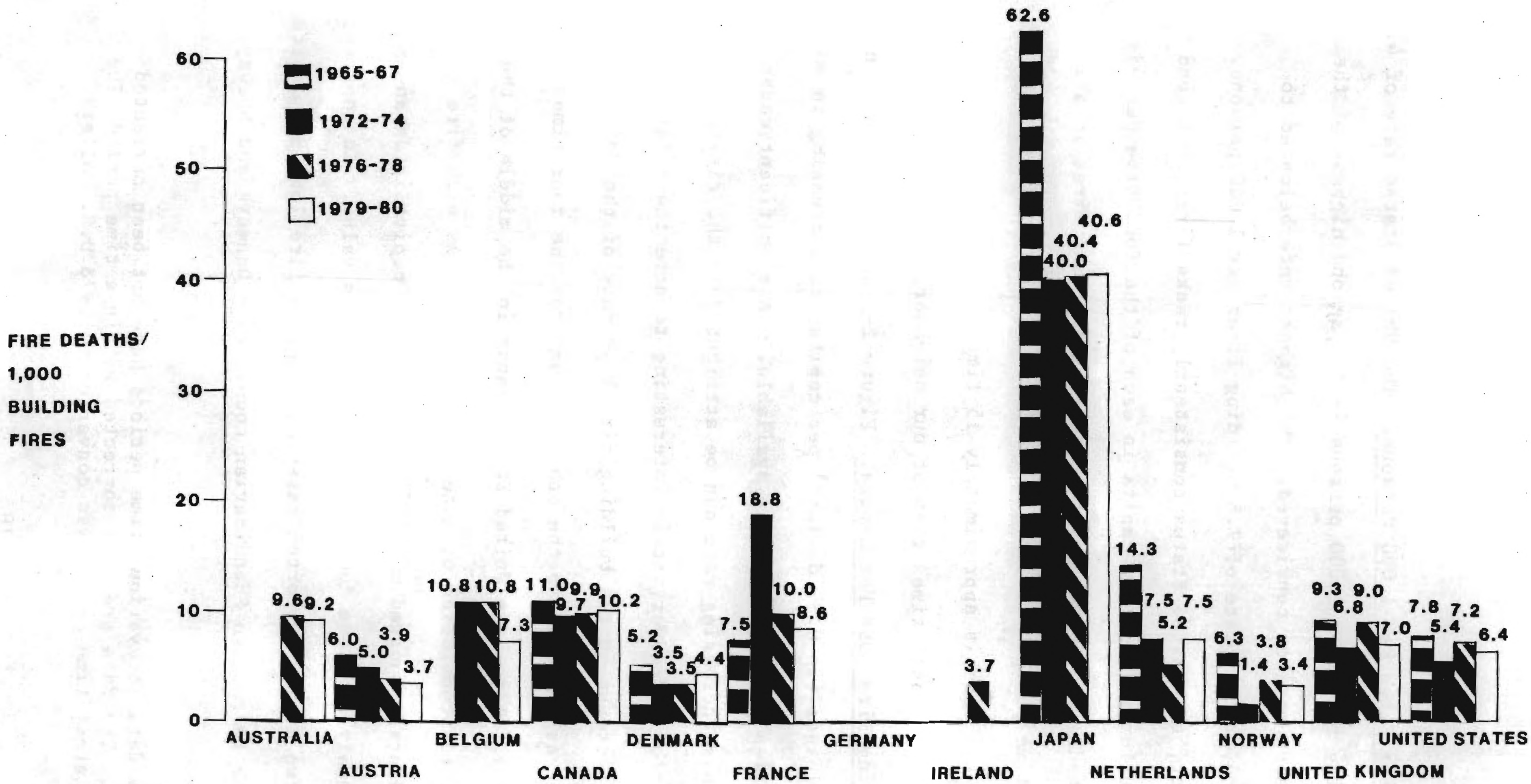

FIGURE 2-2 (CONTINUED). COMPARISONS OF FIRE LOSS INDICES

- Building Fires Per 1,000 Persons. The United States rate of 4.6 building fires per 1,000 persons is the second highest of the seventeen nations considered. The highest rate belonged to Ireland, with a rate of 7.6 building fires per 1,000 persons. In fact, the United States consistently ranks first or second for building fires per capita in each of the four time periods examined. The lowest relative rate of building fires in all four time periods is Japan. The United States building fire incidence rate is approximately 15 times that of Japan, and over one and one-half times that of our neighbor, Canada.
- Building Fire Loss Per Capita. Figure 2-2 shows that building fire losses (in U.S. dollars) per capita are increasing in most countries for which data is available.[1] A significant cause for this increasing rate can be attributed to the rising rate of inflation. However, it is interesting to note the relatively slow increase in the building fire loss rate of the United States as compared to the other nations for the four time periods. Also, the United States ranks in the middle of the countries considered on monetary fire loss. As with fire incidents, reported monetary fire loss per capita in Japan is extremely low, one fourth the United States value. In contrast, the two highest reported rates of monetary fire loss per capita belong to the two Scandinavian countries - Denmark and Norway.

---

[1] The monetary data for various time periods have not been corrected for inflation. The data are only corrected within a time period. The data for the latest time period was converted to 1978 U.S. dollars.

- Building Fire Loss as a Percent of Gross National Product. When fire losses are measured as a fraction of gross national product, they reflect the economic burden of monetary fire losses on the various nations. By this standard, the burden of fire losses has risen slightly over the past several years in most of the countries reported in Figure 2-2. In the last two reporting time periods, only Japan, Norway and the United States exhibited a decline in monetary fire loss as a percent of GNP. As with building fire loss per capita, the largest monetary losses for 1979-80 were in Denmark, Norway, and Ireland. Ireland's reported fire losses have more than tripled over the last four years. The United States is one of the countries that has experienced a fairly consistent fraction of its gross national product lost to fires.
- Fire Deaths Per 1,000,000 Persons. The WHO fire death rates reflected in Figure 2-2 show for most countries a decreasing fire fatality rate over the past decade. The United States and Canada share the highest death rate per million persons among the fifteen nations, almost twice that of all other countries reported (except Ireland).
- Building Fire Loss Per Fire ($1,000's). In order to compare fire losses, it is useful that they be computed on a per fire basis. By this measure, Table 2-1 shows the United States to have one of the lowest monetary fire loss per fire rates. The fire losses of the Netherlands have nearly doubled in the last two time periods. The low United States value could be a function of many factors. It may reflect the fact that more

inconsequential fire incidents are included in the United States data, or the possibility that fires are better controlled in the United States after ignition. It is also possible that loss estimation procedures differ among nations.

- Fire Deaths per 1,000 Building Fires. Although WHO values in Table 2-1 include non-building fires, the ratio of fire deaths to building fires reflects the seriousness of building fire incidents. The fire death rates have remained fairly constant over the four time periods, with the United States ranked in the middle of the countries reported. The death rate in Japan is extraordinarily higher than any of the other countries.

Table 2-2 exhibits the percentage changes of the last two reporting periods (1979-80 versus 1976-78) for the fire loss measures of Table 2-1. All measures which involved monetary units are compared on a 1977 basis. A detailed analysis of the United States' calculations, which illustrate the numbers generated in Table 2-2, is given in Appendix B.2.

Table 2-2 shows the overall improvement of the United States in all of the six fire loss measures of Table 2-1. For the number of Building Fires/1,000 Persons, only Canada, Denmark, and the Netherlands showed a better rate of improvement than the United States. Similarly, only Norway carried a greater rate of improvement than the United States in Building Fire Loss as Percent of GNP and Building Fire Losses/Fire ($1,000's). The United States showed the greatest rate of improvement over all countries in two categories: $ Building Fire Loss Per Capita and Fire Deaths/1,000,000 Persons. In the final category, Fire Deaths/1,000 Building Fires, only Belgium, France and the United Kingdom had greater rates of improvement than the United States.

TABLE 2-2

PERCENTAGE CHANGES SINCE LAST REPORTING PERIOD

Nation	Building Fires/ 1,000 Persons	$ Building Fire Loss Per Capita[1/]	Building Fire Loss As Percent of GNP	Fire Deaths/ 1,000,000 Persons	Building Fire Losses/ Fire ($1,000's)[1/]	Fire Deaths/ 1,000 Building Fires
	% Change	% Change	% Change	% Change	% Change	% Change
Australia	0.0	-	-	- 9.1	-	- 4.3
Austria	7.7	43.5	9.1	10.0	38.5	- 5.4
Belgium	29.4	-	-	- 8.3	-	-47.9
Canada	-10.3	9.9	3.6	-10.3	19.8	2.9
Denmark	- 6.4	21.9	13.3	7.7	29.0	20.4
France	11.8	12.9	8.8	- 7.1	3.3	-16.3
Germany	-	34.8	5.9	0.0	-	-
Ireland	14.5	-	-	-	-	-
Japan	0.0	34.4	-16.7	0.0	36.6	0.5
Netherlands	-11.1	36.7	23.8	28.6	44.6	30.7
Norway	11.4	8.8	-29.2	0.0	- 5.6	-11.8
United Kingdom	19.0	36.0	14.9	0.0	21.2	-28.6
United States	- 4.3	- 4.8	-17.9	-17.2	- 5.0	-12.5

[1/] All measures involving monetary units are compared on a 1977 basis.

In the two categories involving monetary values, it is interesting to note the large percentage increase of most nations, even after a correction for inflation as compared to other fire loss measures. Note, especially, the high percentage changes of Denmark and the Netherlands.

It is possible that many of the larger percentage changes (say greater than ± 25%) are the result of reporting phenomena, or perhaps the result of the occurrence of unusually severe fires. The Netherlands is particularly striking, since all measures of fire loss have increased dramatically in the face of an 11% decline in building fires per capita.

2.3 The Uniqueness of Japan

Some researchers have suggested that the attitudes and opinions of a society affect fire incidence within a nation. The unique standing of Japan in the comparisons of Table 2-1 and Figure 2-2 reflect such a cultural element. Reported values for numbers of fires and monetary loss in Japan are extraordinarily low. On the other hand, loss per fire and especially deaths per fire are exceptionally large. Japanese fire professionals [34] suggest that the traditional burnability of the Japanese living environment is closely connected with both these unusual standings. The high risk associated with a fire is reflected in the large losses per fire. A long history of large fires--especially ones connectd with earthquakes and war--has produced a strong cultural concern that is expressed in low fire incidence. It is reported that great shame and embarassment falls on any family responsible for a fire in a neighborhood. It should be noted that such societal pressure may lower the likelihood of reporting a small fire, and contribute to the apprarent and unique position of Japan in Table 2-1 and Figure 2-2.

3. COMPARISON BY OCCUPANCY AND CAUSE

Any set of fire statistics for an entire nation reflects a host of fire problems presented by different structure types (or occupancies) where fires arise and by different causal factors leading to the fires. Most agencies producing fire statistics recognize this fact by subdividing statistics according to occupancy and/or cause. An effort is under way to develop a standard international fire data system, and a draft proposal for such a system is now being circulated in a committee of the International Standards Organization [33]. However, unfortunately, a standard that would provide for uniform reporting of fire incidents on an international scale has not yet been adopted; consequently, reporting schemes vary significantly from nation to nation. Still, insight can be gained if these classification schemes can be brought into approximate harmony. The analyses of this section are based on the recategorization and interpolation of national fire reports to achieve such harmony. Appendix B.4 details the calculations performed.

3.1 Comparison of Broad Occupancy Classifications

FEMA fire experience statistics [21] classify structure type or occupancy into four broad categories: residential structures, non-residential structures, mobile property (not used as a residence), and outside property. Table 3-1 shows 1979-80 breakdowns of fire losses in six nations according to this occupancy classification. Numbers of fires, numbers of fire deaths, and monetary loss due to fire are estimated for each occupancy. Per capita rates are also computed. Dashes in the table reflect values not available from the indicated country.

Results in Table 3-1 can be evaluated from two general points of view. A first question is "What is the general role of each occupancy

TABLE 3-1

FIRE LOSS BY MAJOR OCCUPANCY CLASS

	CANADA			JAPAN			NETHERLANDS			NEW SOUTH WALES (1979)			UNITED KINGDOM (1979)			UNITED STATES (avg. 1979, 1980)		
	Number	Rate	%	Number	Rate	%	Number	Rate	%	Number	Rate	%	Number	Rate	%	Number	Rate	%
Residential																		
Fires (1,000's)	40.6	1.7	49%	19.3	.17	30%	7.2	.52	27%	3.7	.73	11%	61.7	1.1	20%	714.1	3.30	25%
Deaths	578	24.8	84%	975	8.5	62%	-	-	-	53	10.4	-	664	11.9	81%	5054	23.4	80%
$ Loss (1,000,000's)	251.0	10.8	39%	200.3	1.8	32%	47.8	3.4	16%	16.9	3.3	-	-	-	-	2407.3	11.1	45%
Non-Residential Structure																		
Fires (1,000's)	10.2	0.4	12%	18.0	.17	30%	8.8	.64	33%	2.5	.49	8%	55.6	.99	18%	282.2	1.30	10%
Deaths	55	2.4	8%	121	1.1	8%	-	-	-	6	1.2	-	63	1.1	8%	456	2.1	7%
$ Loss ($1,000,000's)	254.7	10.9	39%	398.1	3.5	64%	247.2	17.8	80%	-	-	-	-	-	-	2110.8	9.8	-39%
Mobile Property																		
Fires (1,000's)	20.8	0.9	25%	3.9	.03	6%	3.3	.24	12%	4.6	.91	14%	33.4	.60	11%	475.4	2.20	17%
Deaths	45	1.9	7%	99	0.9	6%	-	-	-	-	-	-	52	0.9	6%	638	2.9	10%
$ Loss ($1,000,000's)	-	-	-	10.9	0.1	2%	10.2	0.7	3%	-	-	-	-	-	-	587.8	2.7	11%
Outdoor Property																		
Fires (1,000's)	11.6	0.5	14%	21.6	.19	34%	7.5	.54	28%	22.1	4.35	67%	159.9	2.86	51%	1324.6	6.12	48%
Deaths	8	0.3	1%	369	3.2	24%	-	-	-	-	-	-	40	0.7	5%	209	1.0	3%
$ Loss (1,000,000's)	-	-	-	15.1	0.1	2%	2.0	.14	1%	-	-	-	-	-	-	279.3	1.3	5%
Total																		
Fires (1,000's)	83.2	3.6	100%	63.8	.56	100%	26.8	1.93	100%	32.9	6.48	100%	310.6	5.55	100%	2796.3	12.92	100%
Deaths	686	29.5	100%	1564	13.7	100%	94	6.8	100%	-	-	-	819	14.6	100%	6357	29.4	100%
$ Loss (1,000,000's)	645.7	27.7	100%	624.4	5.5	100%	307.2	22.2	100%	-	-	-	-	-	-	5385.2	24.9	100%

Notes: Percentages shown are formed from the ratio of the number in occupancy class divided by number in total, multiplied by 100.

Monetary losses are in 1979 U.S. dollars.

Rates for Fires are fires/thousand persons. Rates for Deaths are deaths/million persons. Rates for Losses are dollar loss/person.

Death rates under total category reflect the most recent World Health Organization values [39] for each country (1975-1979). Death by occupancy class are scaled to meet WHO values then converted to the death rates in this table.

Fire deaths (used to determine death rates by occupancy class) are based on the following years for the various nations: Canada (1977), Japan (1978), Netherlands (1978), New South Wales (1977), United Kingdom (1977), United States (1977).

classification in the fire problems of the nations presented?" Observations about the various occupancy classes include the following:

- Residential Fires. Residential fires contribute from 11% to 49% of the fire incidence in the countries reflected in Table 3-1. However, residential fires lead to approximately three quarters of all fire fatalities. Residential fires cause monetary losses of 32% - 45% for all countries except the Netherlands, where the monetary loss due to such fires is only 16% of the total.
- Non-Residential Structures. The number of non-residential structure fires has two modes in Table 3-1. For three nations the value is approximately 10% of all fires, and for two nations the values are 30% and 33% of all fires. (The remaining nation has a value of 18%). These fires account for a large part of the monetary loss. In the United States and Canada, residential and non-residential monetary losses are approximately equal, but in Japan and the Netherlands non-residential losses are much greater than residential monetary losses. In contrast, non-residential structures account for relatively small numbers of fire fatalities--approximately 8% in the countries considered.
- Mobile and Outside Propery. As already noted above, reporting of vehicle and outdoor fires varies substantially from country to country. However, results in Table 3-1 show a consistent pattern of at least 40% of all fire incidents taking place in vehicles or out of doors. Much smaller proportions of the numbers of fire fatalities and monetary fire loss are attributed to such fires.

A second way of analyzing the results in Table 3-1 is to ask "How does the mix of fire loss in different occupancies for the United States differ from that of other countries?" As with the earlier analyses in Selected International Comparisons of Fire Losses [2,28], the most important observation of this type apparent in Table 3-1 is that residential fires seem to be a more significant component of the United States fire problem than they are for other countries, excepting Canada.

- Fire Incidence. The fraction of fire incidence in the United States and Canada in residential structures is more than twice that in non-residential structures. For Japan, the Netherlands, the United Kingdom and Australia's New South Wales, numbers of residential and non-residential fires are much more equal.
- Deaths. The ratio of residential to non-residential fire deaths varies from 8.0 up to 12.0 for the six countries reported in Table 3-1. However, fire deaths are heavily concentrated in residential fires for all countries, and (as noted in Section 2) the United States rate of fire deaths per capita is much higher than for the other nations except Canda.
- Monetary Loss. In the United States, the fractions of monetary fire loss due to residential and non-residential fires are nearly equal. In Japan, the non-residential loss is twice the residential loss, and in the Netherlands non-residential loss is five times the residential loss.

3.2 Residential Fires

From the discussion of the previous section, it appears that residential fires are of particular interest in explaining the relationship between the United States' fire problem and that of other developed countries. Comparable detail on such fires is available for the Netherlands, the United Kingdom, and New South Wales in Australia.

Table 3-2 presents numbers of fires and per capita rates for these countries. For all countries except the Netherlands, values are subdivided by the type of residential occupancy. Except for the United Kingdom, the information is also classified by the principal cause of the fire.[1]

Turning first to cause classifications, the following points are indicated:

- Cooking Fires. Cooking fires are the cause for over 30% of all residential fires in New South Wales, whereas they are the cause for only approxmately 15% of residential fires in the United States and the Netherlands. However, the United States' per capita rate is nearly 2 1/2 times that of New South Wales and over three times that of the Netherlands.
- Smoking Fires. Smoking fires cause approximately 10% of residential fires in the United States and New South Wales, 2 1/2 times the percent of fires in the Netherlands.
- Heating Fires. Heating fires are the leading cause of residential fires in the United States and the Netherlands but only the fifth ranked in New South Wales. Climatic variations may contribute to the differences in such fires.
- Incendiary/Suspicious Fires. Incendiary and suspicious fires are a significant cause of residential fires in the United

---

[1] Fires with unknown causes are distributed proportionately.

TABLE 3-2

RESIDENTIAL FIRES BY CAUSE AND OCCUPANCY CLASS

			COOKING	SMOKING	HEATING	INCENDIARY/ SUSPICIOUS	ELECTRICAL DISTRIBUTION
ONE AND TWO FAMILY	UNITED STATES	-No.	73328	33142	129372	52656	39635
		-Rate	33.9	15.3	59.8	24.3	18.3
	NEW SOUTH WALES	-No.	750	263	264	115	324
		-Rate	14.8	5.2	5.2	2.3	6.4
	UNITED KINGDOM	-No.	-	-	-	-	-
		-Rate	-	-	-	-	-
APARTMENTS, TENEMENTS, AND FLATS	UNITED STATES	-No.	39716	24877	8333	23599	6303
		-Rate	16.0	11.5	3.9	10.9	2.9
	NEW SOUTH WALES	-No.	353	137	52	34	82
		-Rate	7.0	2.7	1.0	0.7	1.6
	UNITED KINGDOM	-No.	-	-	-	-	-
		-Rate	-	-	-	-	-
MOBILE HOMES	UNITED STATES	-No.	2851	1586	5611	2062	4065
		-Rate	1.3	0.7	2.6	1.0	1.9
	NEW SOUTH WALES	-No.	-	-	-	-	-
		-Rate	-	-	-	-	-
	UNITED KINGDOM	-No.	-	-	-	-	-
		-Rate	-	-	-	-	-
HOTELS, MOTELS, & INNS	UNITED STATES	-No.	926	4171	858	2331	724
		-Rate	0.4	1.9	0.4	1.1	0.3
	NEW SOUTH WALES	-No.	24	29	11	6	16
		-Rate	0.5	0.6	0.2	0.1	0.3
	UNITED KINGDOM	-No.	412	390	183	265	144
		-Rate	0.7	0.7	0.3	0.5	0.3
OTHER RESIDENTIAL	UNITED STATES	-No.	1418	1006	2816	1860	664
		-Rate	0.7	0.5	1.3	0.9	0.3
	NEW SOUTH WALES	-No.	-	-	-	-	-
		-Rate	-	-	-	-	-
	UNITED KINGDOM	-No.	-	-	-	-	-
		-Rate	-	-	-	-	-
TOTAL RESIDENTIAL	UNITED STATES	-No.	113239	64782	146990	22508	51391
		-Rate	52.3	29.9	67.9	38.1	23.8
		-Percent	15.9%	9.1%	20.6%	11.6%	7.2%
	NEW SOUTH WALES	-No.	1127	429	327	155	422
		-Rate	22.2	8.5	6.4	3.1	8.3
		-Percent	30.4%	11.6%	8.8%	4.2%	11.4%
	UNITED KINGDOM	-No.	-	-	-	-	-
		-Rate	-	-	-	-	-
		-Percent	-	-	-	-	-
	NETHERLANDS	-No.	1116	259	1384	448	335
		-Rate	8.1	1.9	10.0	3.2	2.4
		-Percent	15.6%	3.6%	19.3%	6.2%	4.7%

Notes: Incidents of fire are based on the following years of data for the various nations: United States (1979-80), New South Wales (1979), United Kingdom (1979), and the Netherlands (1979).

Rates of fire are per 100,000 persons in the population base.

(continued)

TABLE 3-2 (CONTINUED)

APPLIANCES	CHILDREN PLAYING	OPEN FLAMES, TORCHES	EXPOSURE	NATURAL	OTHER	TOTAL	PERCENT OF ALL RESIDENTIAL STRUCTURES
32136	30279	24118	15030	7314	81848	518858	72.7%
14.9	14.0	11.1	6.9	3.4	37.8	239.8	
298	-	229	-	16	457	2714	73.1%
5.8	-	4.5	-	0.3	9.0	53.5	
-	-	-	-	-	-	38269	63.7%
-	-	-	-	-	-	68.4	
6877	9264	5854	3037	648	21097	144605	20.2%
3.2	4.3	2.7	1.4	0.3	9.8	66.8	
85	-	23	-	-	97	863	23.2%
1.7	-	0.5	-	-	1.9	17.0	
-	-	-	-	-	-	17223	28.7%
-	-	-	-	-	-	30.8	
2074	723	1037	956	252	5001	26218	3.7%
1.0	0.3	0.5	0.4	0.1	2.3	12.1	
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
668	129	466	191	98	1715	12277	1.7%
0.3	0.1	0.2	0.1	0.05	0.8	5.7	
10	-	12	-	-	27	135	3.6%
0.2	-	0.2	-	-	0.5	2.7	
39	22	86	-	2	230	1773	3.0%
0.1	0.04	0.2	-	0.004	0.4	3.2	
660	361	442	145	96	2682	12150	1.7%
0.3	0.2	0.2	0.1	0.04	1.2	5.6	
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	
-	-	-	-	-	-	2788	4.6%
-	-	-	-	-	-	5.0%	
42415	40756	31917	19359	8408	112343	714108	
19.6	18.8	14.8	8.9	3.9	51.9	330.1	
5.9%	5.7%	4.5%	2.7%	1.2%	15.7%	100%	
391	-	264	-	16	581	3712	
7.7	-	5.2	-	0.3	11.4	73.1	
10.5%	-	7.1%	-	0.4%	15.7%	100%	
-	-	-	-	-	-	60053	
-	-	-	-	-	-	107.4	
-	-	-	-	-	-	100%	
244	1213	310	15	37	1811	7172	
1.8	8.8	2.2	0.1	0.3	13.1	51.8	
3.4%	16.9%	4.3%	0.2%	0.5%	25.3%	100%	

Notes (continued): Percent of all Residential Structures along the right hand column are obtained by dividing the fire incidents for the occupancy class by total fire incidents, then multiplying the result by 100.

Percents appearing for each ratio in the row entitled Total Residential represent the distribution of residential fires by cause.

States, where they are ranked third. Many nations are experiencing a rapid increase in arson. For example, the New South Wales Standing Committee on arson was recently formed to coordinate the fight against this form of crime.

- Children Playing Fires. Children playing fires form only 5% of residential fires in the United States. In the Netherlands the 16.9% entry is associated with "carelessness, playing with fire," but this figure is not necessarily limited to children.

Notwithstanding the differences between categories noted above, the most important observation that can be drawn from Table 3-2 is that, in every category, the per capita rate of residential fire incidence in the United States is significantly higher than the other countries reported. This disparity suggests that the difference between the United States and other developed countries in per capita fire incidence will only be reduced if the elements of residential fire can be restricted. These might be remedied by more rigorous home construction codes and greater public awareness of the need for home fire safety.

3.3 Non-Residential Structure Fires

Table 3-3 presents a detailed cause versus occupancy analysis of fires in non-residential structures in the United States, New South Wales, the United Kingdom and the Netherlands. As with Table 3-2, results in Table 3-3 should be treated with some caution because of numerous problems in defining categories. However, the results do offer some useful insights:

- Data for all four countries show that stores and offices and manufacturing occupancies are the sites of the first, second, or third highest number of non-residential fires for all four countries. Stores and offices account for approximately 15% to 30% of non-residential fires; manufacturing sites account for an additional 7% to 17%.

- Results for public assembly occupanices (theatres, restaurants, auditoriums, etc.) show some variation among the countries. Some 9.9% of non-residential fires in the United States and 7.1% of non-residential fires in the United Kingdom are classified in this category, but 16.7% of New South Wales fires and 32.2% of the Netherlands fires occur in public assembly occupancies.
- Vacant/Construction fires in New South Wales and the United Kingdom represent an unusually high percentage of the total for non-residential fires. However, it is possible that these apparent disparities are a consequence of data gathering and calssification procedures. Fires in vacant buildings and buildings under construction are often reported on short data forms [27]. This relatively smaller paper workload on fire officials sometimes biases data toward the vacant/construction category.

Some useful insights can be obtained by comparing the cause summary at the end of Table 3-3:

- Incendiary and suspicious fires appear to contribute a greater fraction of non-residential fires in the United States than in the other two countries for which data is available. Values in Table 3-3 show that 25.6% of United States non-residential fires are attributed to this cause while only 7% to 8% of those in New South Wales and the Netherlands are classified incendiary and suspicious. This fact supports the theory that arson is a significant factor in the relatively greater fire incidence in

TABLE 3-3

NON-RESIDENTIAL FIRES BY CAUSE AND OCCUPANCY CLASS

			COOKING	SMOKING	HEATING	INCENDIARY/ SUSPICIOUS	ELECTRICAL DISTRIBTUION
PUBLIC ASSEMBLY	UNITED STATES	-No.	7564	1876	1904	6301	2822
		-Rate	3.5	0.9	0.9	2.9	1.3
	NEW SOUTH WALES	-No.	159	34	12	38	46
		-Rate	3.1	0.7	0.2	0.7	0.9
	UNITED KINGDOM	-No.	1245	461	322	493	424
		-Rate	2.2	0.8	0.6	0.9	0.8
	NETHERLANDS	-No.	119	47	60	137	63
		-Rate	0.9	0.3	0.4	1.0	0.5
EDUCATION	UNITED STATES	-No.	524	842	739	11640	1180
		-Rate	0.2	0.4	0.3	5.4	0.5
	NEW SOUTH WALES	-No.	5	7	8	33	16
		-Rate	0.1	0.1	0.2	0.7	0.3
	UNITED KINGDOM	-No.	118	102	118	686	120
		-Rate	0.2	0.2	0.2	1.2	0.2
	NETHERLANDS	-No.	3	7	19	120	16
		-Rate	0.02	0.05	0.1	0.9	0.1
INSTITUTIONS	UNITED STATES	-No.	1681	6248	874	7892	1634
		-Rate	0.8	2.9	0.4	3.6	0.8
	NEW SOUTH WALES	-No.	18	38	5	12	23
		-Rate	0.4	0.7	0.1	0.2	0.5
	UNITED KINGDOM	-No.	-	-	-	-	-
		-Rate	-	-	-	-	-
	NETHERLANDS	-No.	22	25	9	65	16
		-Rate	0.2	0.2	0.06	0.5	0.1
STORES & OFFICES	UNITED STATES	-No.	1884	4186	4871	12811	10657
		-Rate	0.9	1.9	2.3	5.9	4.9
	NEW SOUTH WALES	-No.	29	80	19	49	90
		-Rate	0.6	1.6	0.4	1.0	1.8
	UNITED KINGDOM	-No.	-	-	-	-	-
		-Rate	-	-	-	-	-
	NETHERLANDS	-No.	33	41	62	132	106
		-Rate	0.2	0.3	0.4	1.0	0.8
BASIC INDUSTRY	UNITED STATES	-No.	104	214	922	770	2513
		-Rate	0.05	0.1	0.4	0.4	1.2
	NEW SOUTH WALES	-No.	2	11	5	4	14
		-Rate	0.04	0.2	0.1	0.08	0.3
	UNITED KINGDOM	-No.	-	-	-	-	-
		-Rate	-	-	-	-	-
	NETHERLANDS	-No.	11	6	83	22	26
		-Rate	0.08	0.04	0.6	0.2	0.2
MANUFACTURING	UNITED STATES	-No.	1068	1544	2785	3356	3402
		-Rate	0.5	0.7	1.3	1.6	1.6
	NEW SOUTH WALES	-No.	11	26	4	10	62
		-Rate	0.2	0.5	0.08	0.2	1.2
	UNITED KINGDOM	-No.	-	-	-	-	-
		-Rate	-	-	-	-	-
	NETHERLANDS	-No.	17	15	63	34	43
		-Rate	0.1	0.1	0.5	0.2	0.3

TABLE 3-3 (CONTINUED)

APPLIANCES	CHILDREN PLAYING	OPEN FLAMES, TORCHES	EXPOSURE	NATURAL	OTHER	TOTAL	PERCENT OF ALL NON-RESIDENTIAL STRUCTURES
1279 0.6	302 0.1	882 0.4	602 0.3	307 0.1	4181 1.9	28018 12.9	9.9%
9 0.2	- -	14 0.3	- -	- -	97 1.9	409 8.1	16.7%
47 0.1	240 0.4	196 0.4	- -	54 0.1	487 0.9	3969 7.1	7.1%
13 0.1	980 7.1	63 0.5	2 0.01	13 0.1	1342 9.7	2839 20.5	32.2%
544 0.3	577 0.3	627 0.3	224 0.1	209 0.1	3489 1.6	20591 9.5	7.3%
1 0.02	- -	7 0.1	- -	2 0.04	31 0.6	110 2.2	4.5%
8 0.01	300 0.5	147 0.3	- -	15 0.03	251 0.4	1865 3.3	3.4%
3 0.02	85 0.6	21 0.2	- -	3 0.02	100 0.7	377 2.7	4.3%
2635 1.2	108 0.05	1497 0.7	67 0.03	160 0.1	4129 1.9	26923 12.4	9.5%
24 0.5	- -	6 0.1	- -	2 0.04	42 0.8	170 3.3	6.9%
- -	- -	- -	- -	- -	- -	2757 4.9	5.0%
16 0.1	29 0.2	19 0.1	- -	2 0.01	85 0.6	288 2.1	3.3%
5746 2.7	790 0.4	3474 1.6	2659 1.2	1001 0.5	12704 5.9	60782 28.1	21.5%
25 0.5	- -	24 0.5	- -	1 0.02	187 3.7	504 19.9	20.5%
- -	- -	- -	- -	- -	- -	8393 15.0	15.1%
15 0.1	973 7.0	95 0.7	3 0.02	15 0.1	886 6.4	2361 17.0	28.6%
380 0.2	162 0.1	692 0.3	404 0.2	412 0.2	2926 1.4	9496 4.4	3.4%
4 0.08	- -	21 0.4	- -	7 0.1	80 1.6	148 2.9	6.0%
- -	- -	- -	- -	- -	- -	5555 9.9	10.0%
11 0.08	49 0.4	38 0.3	10 0.07	32 0.2	188 1.4	476 3.4	5.4%
2144 1.0	336 0.2	4269 2.0	1204 0.6	2207 1.0	18562 8.6	40874 18.9	14.5%
2 0.04	- -	101 2.0	- -	9 0.2	203 4.0	428 8.4	17.4%
- -	- -	- -	- -	- -	- -	7315 13.1	13.2%
13 0.09	17 0.1	156 1.1	3 0.02	24 0.2	296 2.1	681 4.9	7.7%

TABLE 3-3 (CONTINUED)

			COOKING	SMOKING	HEATING	INCENDIARY/ SUSPICIOUS	ELECTRICAL DISTRIBUTION
STORAGE	UNITED STATES	-No.	217	901	1361	6166	2091
		-Rate	0.1	0.4	0.6	2.9	1.0
	NEW SOUTH WALES	-No.	6	17	3	10	23
		-Rate	0.1	0.3	0.1	0.2	0.5
	UNITED KINGDOM	-No.	-	-	-	-	-
		-Rate	-	-	-	-	-
	NETHERLANDS	-No.	1	3	9	20	4
		-Rate	0.01	0.02	0.06	0.1	0.3
VACANT/ CONSTRUCTION	UNITED STATES	-No.	61	615	343	11659	363
		-Rate	0.03	0.3	0.2	5.4	0.2
	NEW SOUTH WALES	-No.	2	136	6	32	27
		-Rate	0.04	2.7	0.1	0.6	0.5
	UNITED KINGDOM	-No.	-	-	-	-	-
		-Rate	-	-	-	-	-
	NETHERLANDS	-No.	-	-	6	5	3
		-Rate	-	-	0.04	0.04	0.02
OTHER	UNITED STATES	-No.	1008	2047	3165	11601	2215
		-Rate	0.5	0.9	1.5	5.4	1.0
	NEW SOUTH WALES	-No.	-	-	-	-	-
		-Rate	-	-	-	-	-
	UNITED KINGDOM	-No.	-	-	-	-	-
		-Rate	-	-	-	-	-
	NETHERLANDS	-No.	3	23	15	126	54
		-Rate	0.02	0.2	0.1	0.9	0.4
TOTAL NON-RESIDENTIAL	UNITED STATES	-No.	14108	18471	16961	72193	26874
		-Rate	6.5	8.5	7.8	33.4	12.4
		-Percent	5.0%	6.5%	6.0%	25.6%	9.5%
	NEW SOUTH WALES	-No.	232	349	64	188	301
		-Rate	4.6	6.9	1.3	3.7	5.9
		-Percent	9.5%	14.2%	2.6%	7.7%	12.3%
	UNITED KINGDOM	-No.	-	-	-	-	-
		-Rate	-	-	-	-	-
		-Percent	-	-	-	-	-
	NETHERLANDS	-No.	209	167	326	661	331
		-Rate	1.5	1.2	2.4	4.8	2.4
		-Percent	2.4%	1.9%	3.7%	7.5%	3.8%

Notes: Incidents of fire are based on the following years of data for the various nations: United States (1979-80), New South Wales (1979), United Kingdom (1979), and the Netherlands (1979).

Rates of fire are per 100,000 persons in the population base.

(continued)

APPLIANCES	PLAYING	OPEN FLAMES, TORCHES	EXPOSURE	NATURAL	OTHER	TOTAL	PERCENT OF ALL RESIDENTIAL STRUCTURES
375 0.2	1444 0.7	3006 1.4	1946 0.9	1505 0.7	7792 3.6	26800 12.4	9.5%
2 0.04	- -	9 0.2	- -	- -	56 1.1	128 2.5	5.2%
- -	- -	- -	- -	- -	- -	- -	- -
1 0.01	14 0.1	12 0.09	- -	3 0.02	73 0.5	140 1.0	1.6%
71 0.03	1775 0.8	1806 0.8	656 0.3	101 0.05	2723 1.3	20170 9.3	7.1%
8 0.2	- -	88 1.7	- -	17 0.3	240 4.7	556 11.0	22.7%
- -	- -	- -	- -	- -	- -	16422 29.4	29.5%
1 0.01	1 0.01	5 0.04	- -	- -	17 0.1	38 0.3	0.4%
749 0.3	4932 2.3	2786 1.3	4431 2.0	770 0.4	14805 6.8	48506 22.4	17.2%
- -	- -	- -	- -	- -	- -	- -	- -
- -	- -	- -	- -	- -	- -	9307 16.6	16.7%
7 0.05	808 5.8	168 1.2	3 0.02	5 0.04	395 2.9	1607 11.6	18.2%
13921 6.4 4.9%	10423 4.8 3.7%	19037 8.8 6.7%	12190 5.6 4.3%	6671 3.1 2.4%	71309 33.0 25.3%	282158 130.4 100%	
75 1.5 3.1%	- - -	270 5.3 11.0%	- -	38 0.7 1.5%	936 18.4 38.2%	2453 48.3 100%	
- - -	- - -	- - -	- - -	- - -	- - -	55583 99.4 100%	
80 0.6 0.9%	2956 21.3 33.6%	577 4.2 6.6%	21 0.2 0.2%	97 0.7 1.1%	3382 24.4 38.4%	8807 63.6 100%	

Notes (continued): Percent of all Non-residential Structures along the right hand column are obtained by dividing the fire incidents for the occupancy class by total fire incidents, then multiplying the result by 100.

Percents appearing for each nation in the row entitled Total Non-Residential represent the distribution of non-residential fires by cause.

the United States.

- For New South Wales, the most significant cause of non-residential fires is apparently smoking. The fraction attributed to this cause in the United States is only one-half that of New South wales, although the per capita rate of such fires in the United States is slightly larger.
- A large percentage (33.6%) of the Netherlands non-residential fires are attributed to "carelessness, playing with fire." This percentage is not necessarily limited to children. It is possible that this fact reflects variations in classification systems. Under some reporting schemes, "carelessness, playing with fire" might become a miscellaneous category when a specific cause cannot be determined.

With the exception of the unusual items noted above, the detailed analysis of Table 3-3 fairly closely follows the more aggregate behavior of earlier tables. Per capita rates in the United States are 1 1/2 times those of the other three countries reported.

3.4 Mobile and Outside Fires

Tables 3-4 and 3-5 report the breakdowns that are available for fires in mobile and outside property. The pattern presented for mobile fires parallels that of earlier tables. The per capita United States rate is nearly four to over nine times that of the United Kingdom and the Netherlands, respectively. However, the per capita numbers of vehicles is also higher in the United States. Using world vehicle registration counts available from the Motor Vehicle Manufacturers Association of the United States [20], the mobile United States fires of Table 3-4 represent 3.19 fires per thousand registered vehicles. The comparable values for

TABLE 3-4

MOBILE FIRES BY OCCUPANCY CLASS

		Automobiles	Motor Vehicles	Rail, Water, Air Trans.	Other Mobile	Total Mobile
UNITED STATES	-No.	330855	86439	23148	34926	475368
	-Rate	152.9	40.0	10.7	16.1	219.7
	-Percent	69.6%	18.2%	4.9%	7.3%	100%
UNITED KINGDOM	-No.	21919	8339	817	2354	33429
	-Rate	39.2	14.9	1.5	4.2	59.8
	-Percent	65.6%	24.9%	2.4%	7.0%	100%
NETHERLANDS	-No.	2861	-	282	159	3302
	-Rate	20.6	-	2.0	1.1	23.8
	-Percent	86.6%	-	8.5%	4.8%	100%

Notes: Incidents of fire are based on the following years of data for the various nations: United States (1979-80), United Kingdom (1979), and the Netherlands (1979).

Rates shown are per 1,000 population.

All motor vehicle fires are grouped in the Netherlands statistics.

TABLE 3-5

OUTSIDE FIRES BY OCCUPANCY CLASS

		Refuse	Trees, Grass, Brush	Forest	Crops	Other Outside	Total Outside
UNITED STATES	-No.	456869	669079	-	-	216660	1342614
	-Rate	211.2	309.3	-	-	100.2	620.6
	-Percent	34.0%	49.8%	-	-	16.1%	100%
UNITED KINGDOM	-No.	96214	51204	248	874	11370	159910
	-Rate	172.1	91.6	0.4	1.6	20.3	286.0
	-Percent	60.2%	32.0%	0.2%	0.5%	7.1%	100%
NETHER-LANDS	-No.	638	245	279	61	6268	7491
	-Rate	4.6	1.8	2.0	0.4	45.2	54.1
	-Percent	8.5%	3.3%	3.7%	0.8%	83.7%	100%

Notes: Rates shown are per 100,000 population.

Incidents of fire are based on the following years of data for the various nations: United States (1979-80), United Kingdom (1979), and the Netherlands (1979).

Forest fires in the United States is blank because such incidents are not regularly reported to fire departments, from which incident data is obtained.

the United Kingdom and the Netherlands are 2.02 and 0.76, respectively. Thus, if the greater number of vehicles in the United States are taken into account, the number of vehicle fires in this country may be more typical than implied by the per capita values.

Outside fires are unquestionably the most erratically reported of all fires accounted for in published reports. For example, United States values in Table 3-5 are known to exclude outside fires in federally owned forests. Data for the United Kingdom reflects the fact that only a brief report is collected on incidents of grass or brush fires. Thus, no conclusions could appropriately be drawn from the very limited data in Table 3-5.

4. FATALITY PATTERNS

The statistics on deaths due to "Fire and Flames" accidents available from the World Health Organization (WHO) make it possible to compare fire fatality patterns in many developed countries. Table 4-1 shows the rates per million population of WHO fire fatalities grouped by sex and age of the victim for the countries' latest reporting year. Most countries' latest reporting year is either 1977 or 1978, but ranges from 1975-78. Figures 4-1 and 4-2 compare the values of Table 4-1 to the 1972-74 values of Appendix Table A-5 and the 1975-77 values of Appendix Table A-6.

Figure 4-1 compares the rate of fire fatalities by sex of the victim for each country in the three time periods. For most countries, the rate of fire fatalities is greater for males than for females in the latest reporting year - the one exception being the United Kingdom.

Figure 4-2 confirms the widely held view that fire fatalities fall heavily on the very young and the very old. For the latest reporting year, the United States' per million fire fatality rate for infants 0 to 4 years old was 1.7 times its overall rate. Similarly, the rate for persons over 65 years was 2.7 times the United States' overall rate. Note the extremely high rates of fire fatalities for the elderly in all reporting countries. Several countries (Australia, Austria, Denmark, Finland, and Sweden) have apparently escaped extraordinary fire death rates for infants.

As with other results in this report, the clearest observation in Figures 4-1 and 4-2 is the consistently poor ranking of the United States. Comparisons of fire fatality rates of the United States and Canada exhibit interesting trends. Although the rates for the United

TABLE 4-1

DEATH RATES BY AGE & SEX, LATEST REPORTING YEAR

		0-4	5-14	15-24	25-44	45-64	65+	Total
Australia	M	2	2	5	11	26	62	15
	F	9	2	5	2	10	76	8
	T	8	2	5	7	18	46	12
Austria	M	8	–	4	9	7	43	10
	F	4	–	2	2	7	36	9
	T	6	–	3	6	7	39	10
Belgium	M	61	7	13	7	9	20	14
	F	29	1	13	4	12	23	12
	T	46	4	13	6	11	22	13
Canada	M	49	13	31	33	48	93	38
	F	54	13	13	12	19	56	21
	T	52	13	22	23	33	72	29
Denmark	M	16	3	13	14	20	30	16
	F	–	3	6	6	14	35	11
	T	3	3	9	10	17	33	13
Finland	M	6	3	10	24	58	68	28
	F	–	3	5	1	9	31	8
	T	3	3	7	13	31	45	17
France	M	19	4	11	13	16	51	16
	F	16	4	4	5	10	44	13
	T	17	4	8	9	13	46	14
Germany (F.R.)	M	20	3	7	8	11	30	11
	F	21	1	2	2	7	16	7
	T	21	2	5	5	9	21	9
Japan	M	14	7	6	7	18	99	16
	F	13	4	4	5	7	62	11
	T	14	5	5	6	12	78	14
Netherlands	M	17	9	7	8	6	17	9
	F	9	4	2	3	6	9	5
	T	13	5	4	5	6	12	7
New Zealand	M	7	–	3	7	28	66	13
	F	22	7	–	8	10	49	12
	T	14	3	2	8	19	56	13
Norway	M	14	–	10	14	20	57	17
	F	14	16	10	6	7	34	13
	T	14	8	10	10	13	44	15

TABLE 4-1 (CONTINUED)

		0-4	5-14	15-24	25-44	45-64	65+	Total
Sweden	M	11	5	25	17	27	47	22
	F	8	4	17	5	6	25	10
	T	9	4	21	11	16	35	16
Switzerland	M	32	2	6	5	5	30	9
	F	6	4	-	-	6	18	5
	T	19	3	3	3	5	23	7
United Kingdom	M	17	7	4	6	13	54	14
	F	20	7	4	6	9	54	16
	T	19	7	4	6	11	54	15
United States	M	55	16	19	28	46	105	37
	F	46	14	11	11	23	62	22
	T	50	15	15	19	34	79	29

Notes: Death rates are per million population in the age category indicated.

Latest reporting year for most countries is 1977 or 1978, but ranges from 1975-1978.

Death data are from <u>WHO Statistics Annual: Vital Statistics and Causes of Death</u> [39] and reflect an average for the time period for the latest year available (usually 1977 or 1978).

Population data are from the <u>Statistical Yearbook</u> published by the United Nations [36].

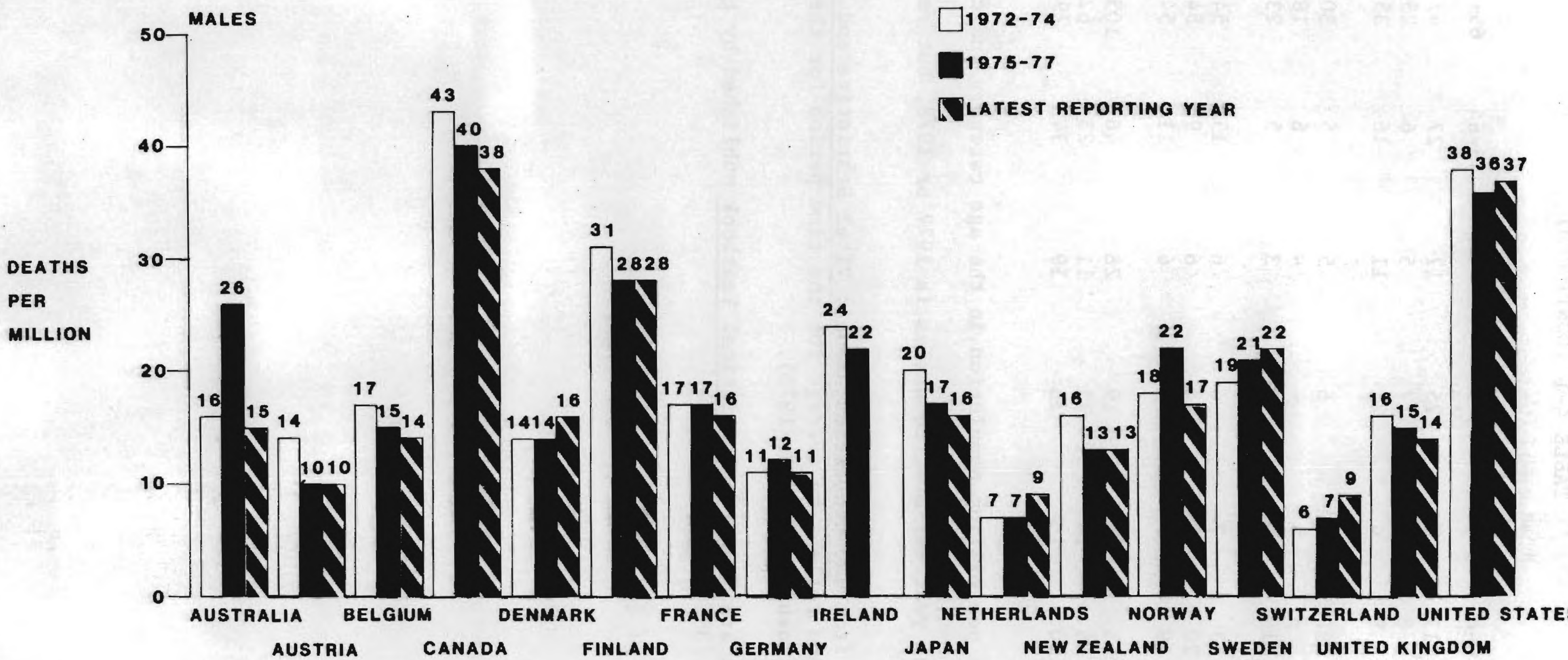

FIGURE 4-1. COMPARISONS OF 1972-74, 1975-77, AND LATEST YEAR FIRE DEATH RATES (PER MILLION POPULATION) BY SEX

Notes: Death data are from WHO Statistics Annual: Vital Statistics and Causes of Death [39] and reflect an average for the time period indicated.

Latest reporting year is usually 1977 or 1978, but ranges from 1975-78.

Population data are from the Statistical Yearbook published by the United Nations [36].

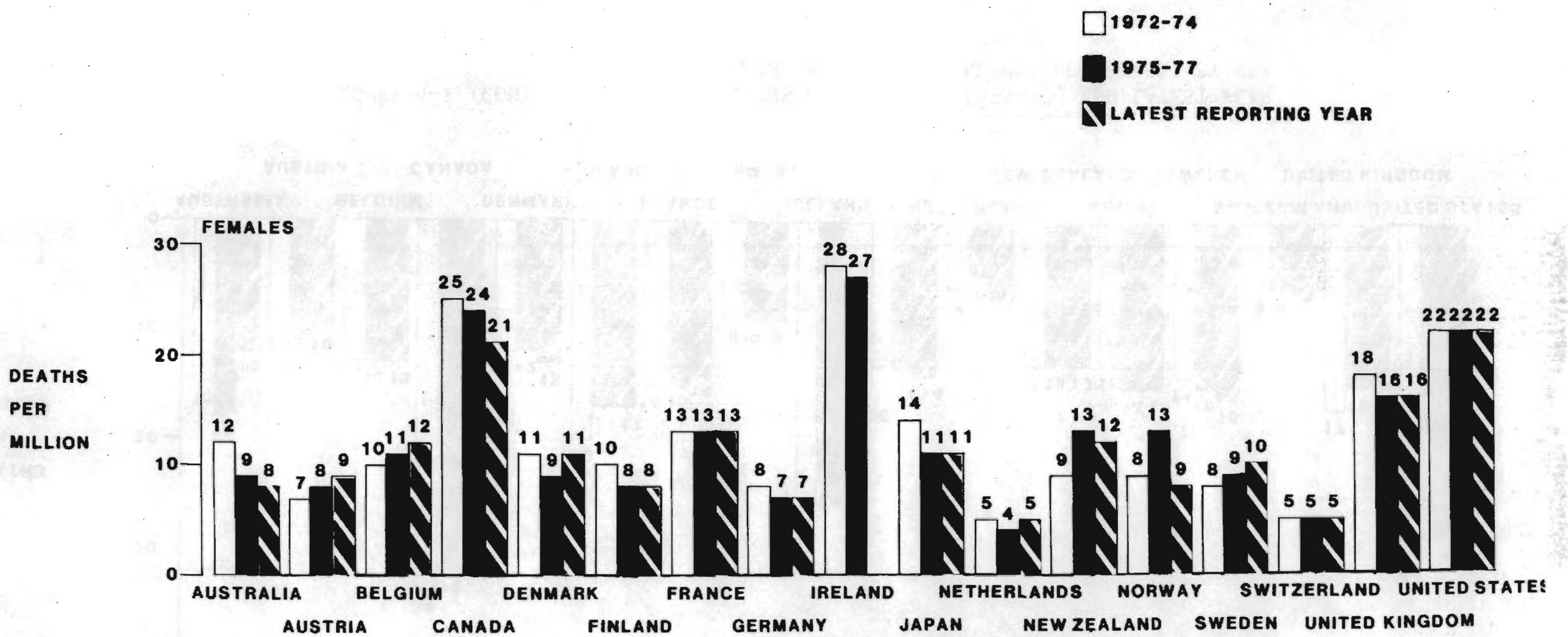

FIGURE 4-1 (CONTINUED). COMPARISONS OF 1972-74, 1975-77, AND LATEST YEAR FIRE DEATH RATES (PER MILLION POPULATION) BY SEX

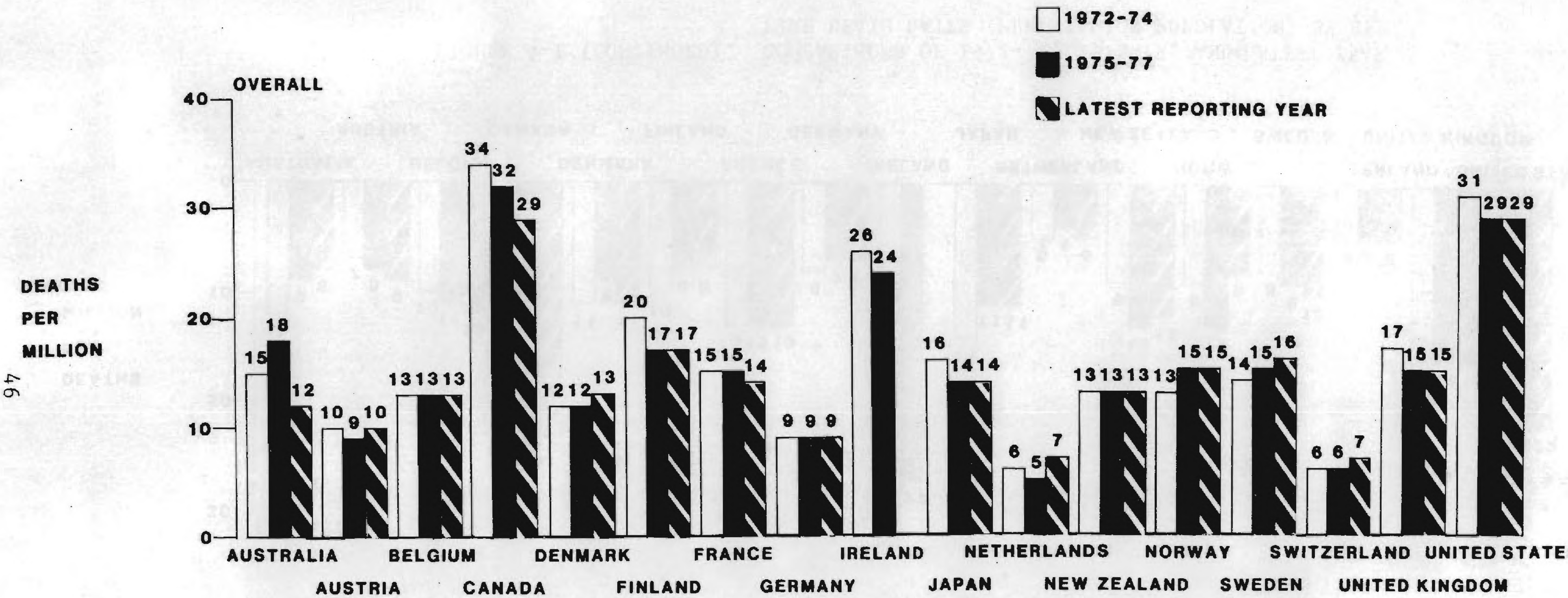

FIGURE 4-1 (CONTINUED). COMPARISONS OF 1972-74, 1975-77, AND LATEST YEAR FIRE DEATH RATES (PER MILLION POPULATION) BY SEX

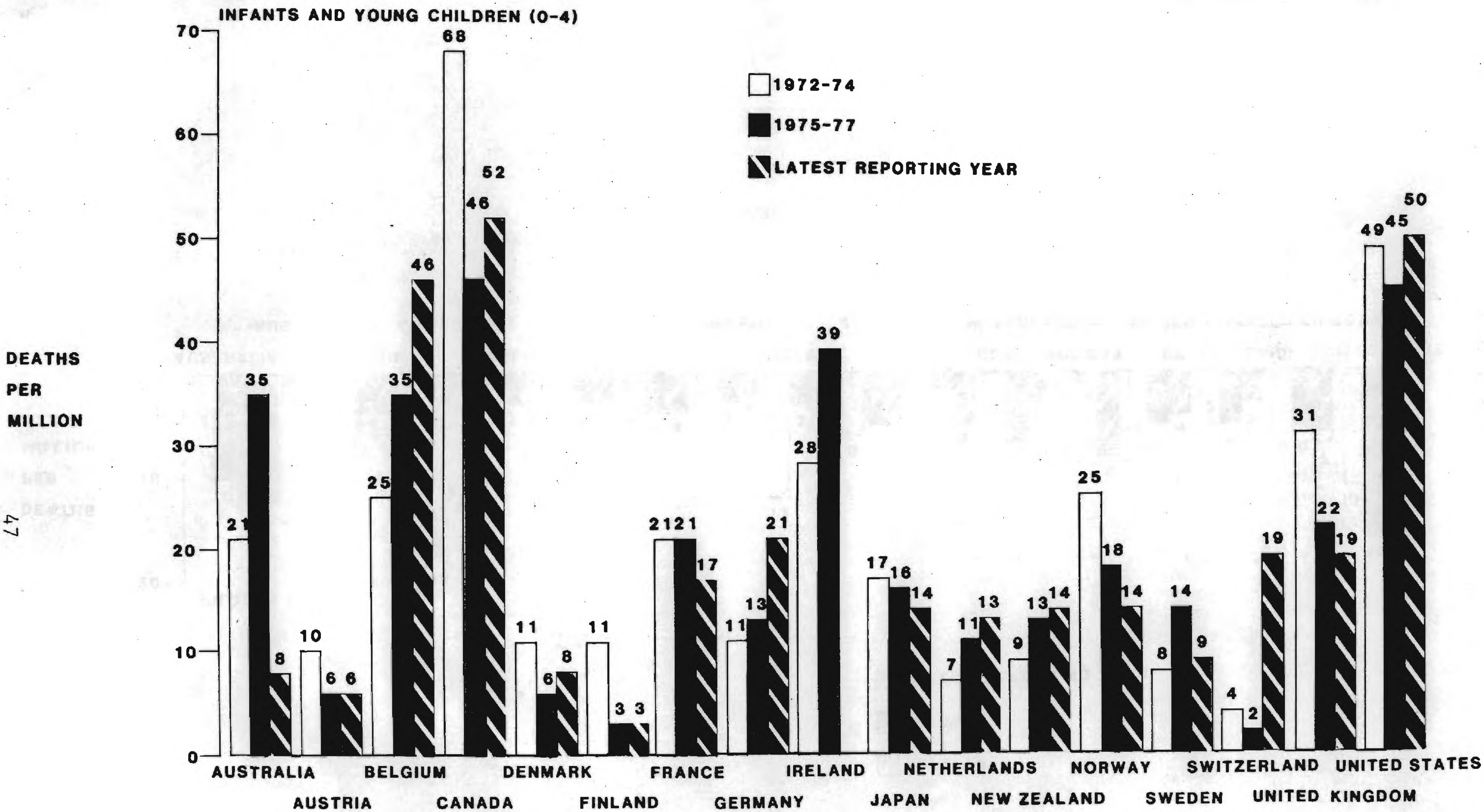

FIGURE 4-2. COMPARISON OF 1972-74, 1975-77, AND LATEST YEAR FIRE DEATH RATES (PER MILLION POPULATIONS) BY AGE

Notes: Death data are from WHO Statistics Annual: Vital Statistics and Causes of Death [39] and reflect an average for the time period indicated.

Latest reporting year is usually 1977 or 1978, but ranges from 1975-78.

Population data are from the Statistical Yearbook published by the United Nations [36].

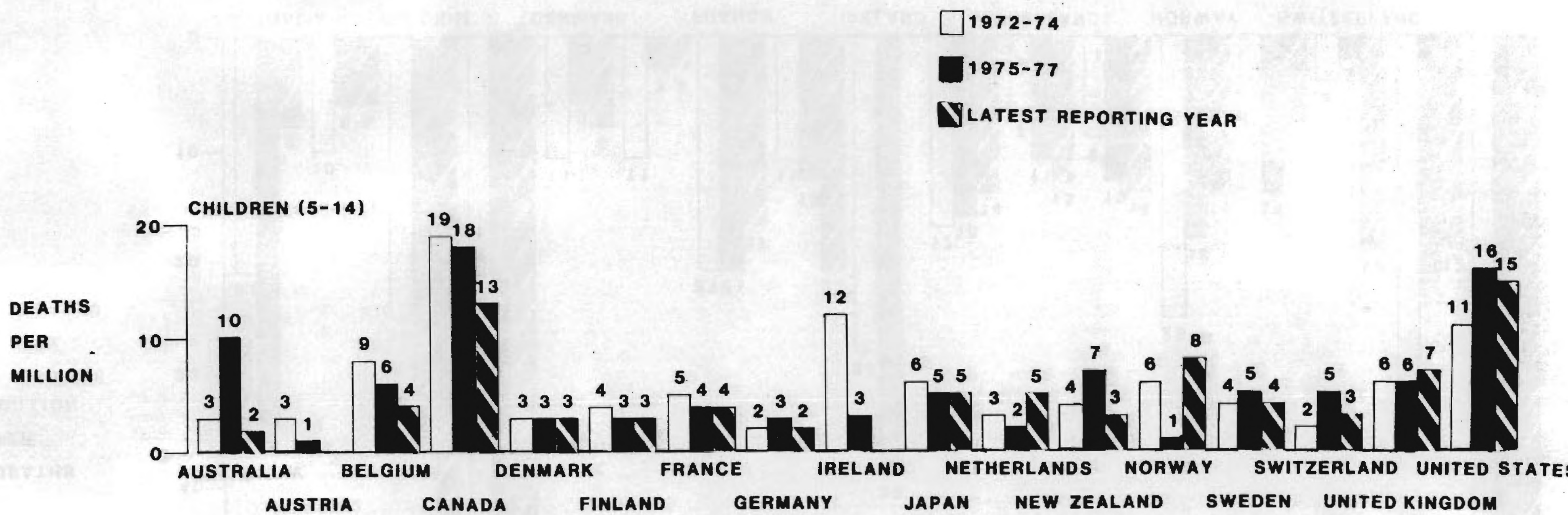

FIGURE 4-2 (CONTINUED). COMPARISON OF 1972-74, 1975-77, AND LATEST YEAR FIRE DEATH RATES (PER MILLION POPULATION) BY AGE

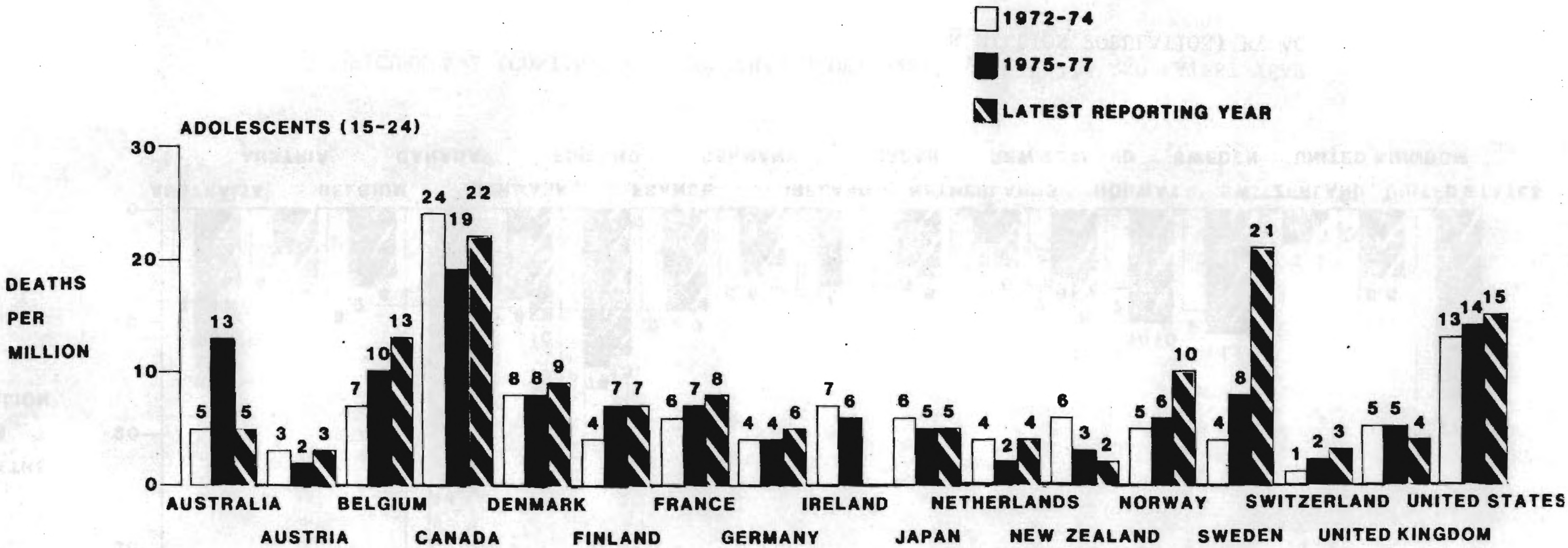

FIGURE 4-2 (CONTINUED). COMPARISON OF 1972-74, 1975-77, AND LATEST YEAR FIRE DEATH RATES (PER MILLION POPULATION) BY AGE

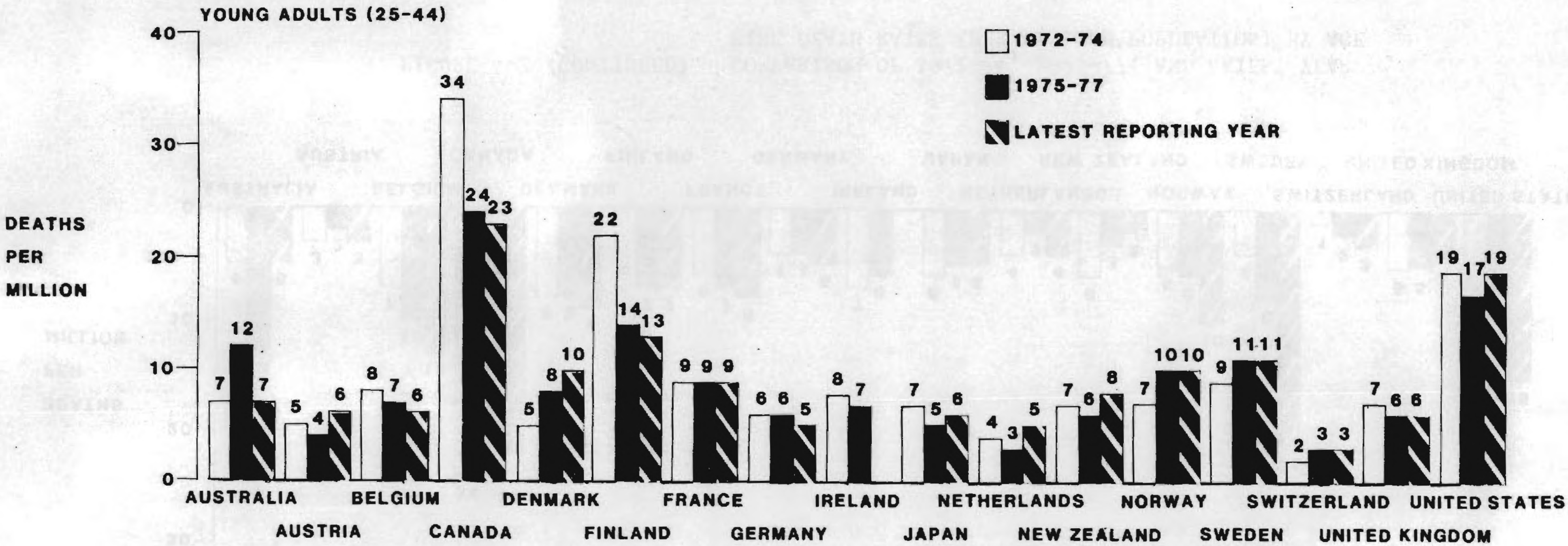

FIGURE 4-2 (CONTINUED). COMPARISON OF 1972-74, 1975-77, AND LATEST YEAR FIRE DEATH RATES (PER MILLION POPULATION) BY AGE

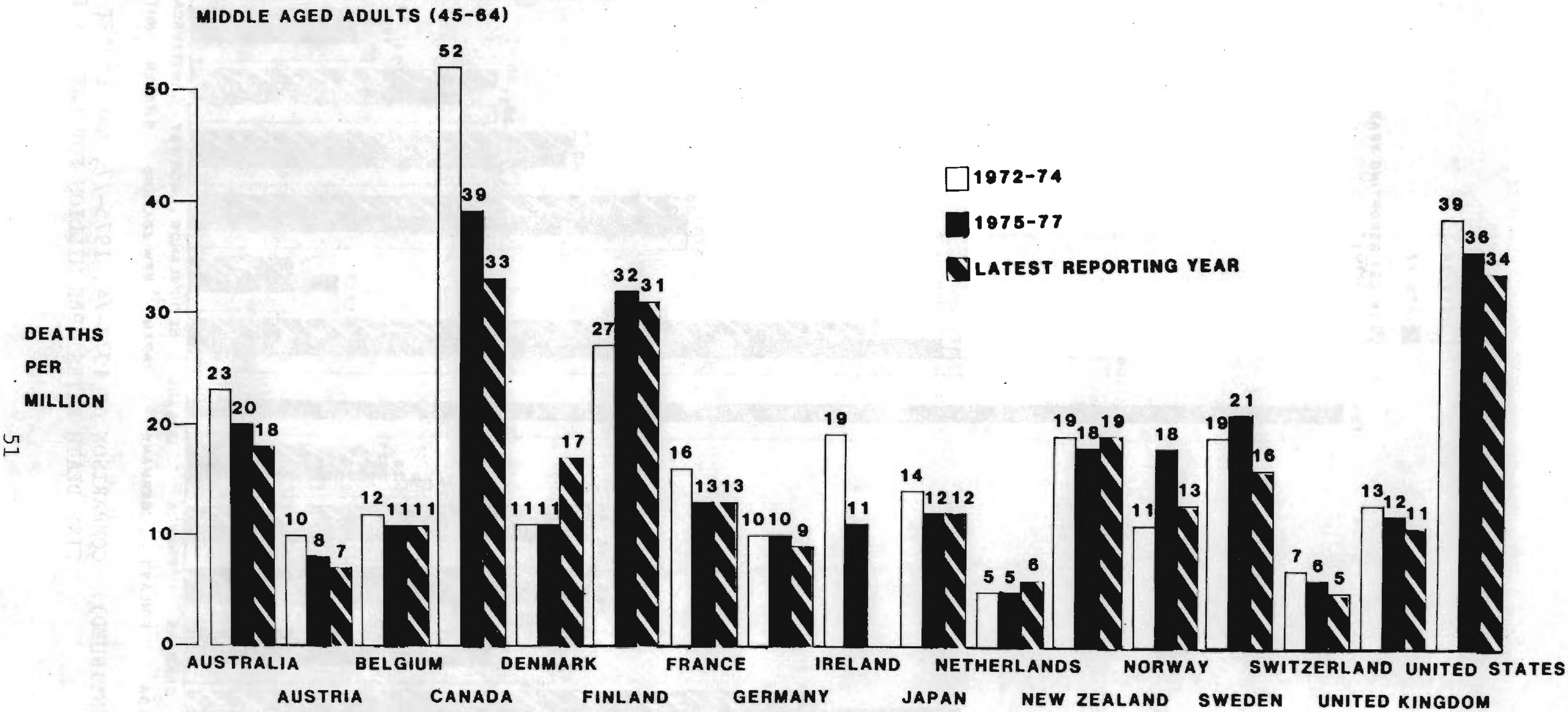

FIGURE 4-2 (CONTINUED). COMPARISON OF 1972-74, 1975-77, AND LATEST YEAR FIRE DEATH RATES (PER MILLION POPULATION) BY SEX

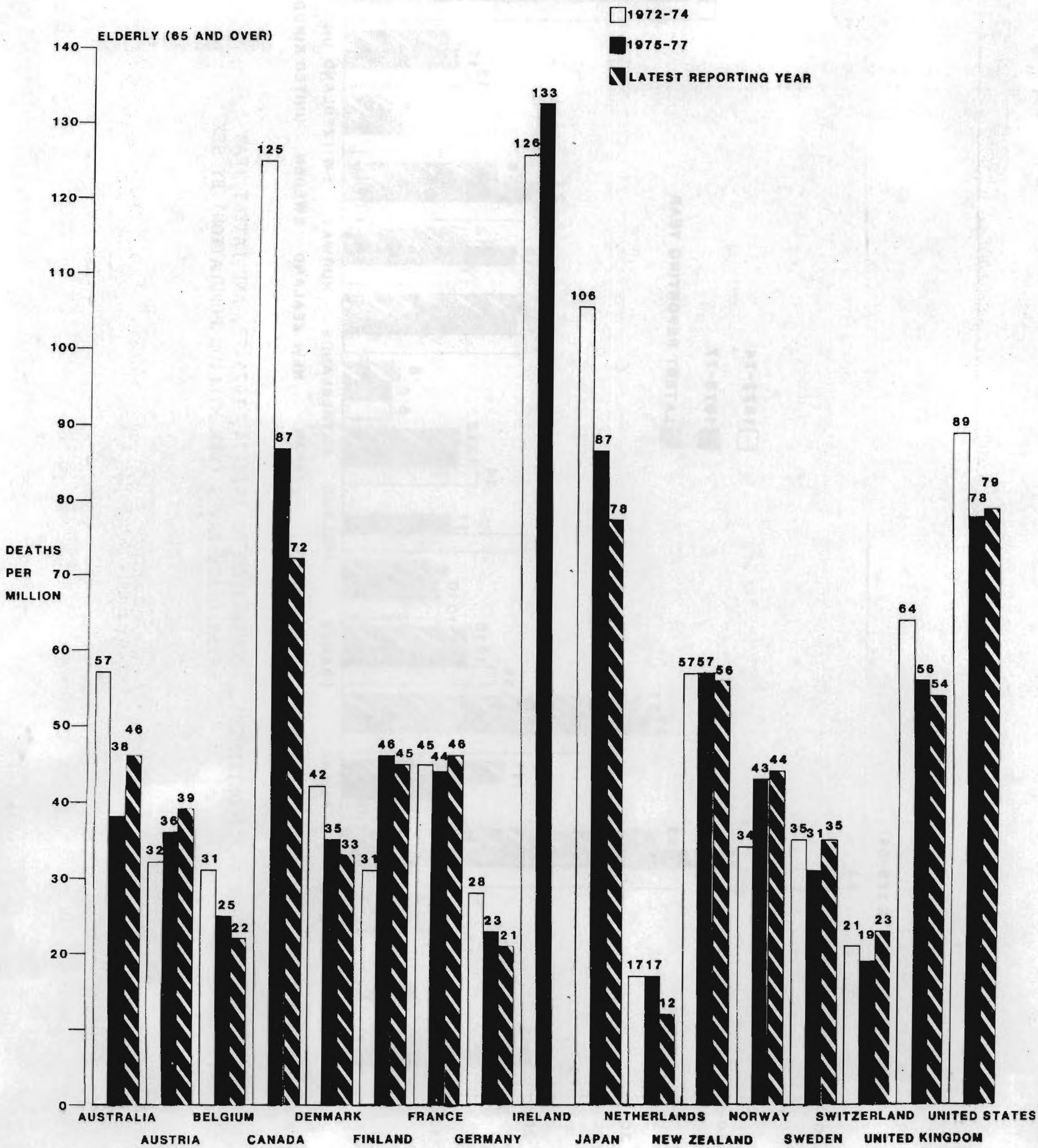

FIGURE 4-2 (CONTINUED). COMPARISON OF 1972-74, 1975-77, AND LATEST YEAR FIRE DEATH RATES (PER MILLION POPULATION) BY AGE

States have stabilized over the three time periods, Canada's rates have decreased to become comparable with the United States. A dramatic decrease has occurred in the over-65 age group for Canada.

5. COMPARISONS OF CITY DATA

For many years, the Tokyo Fire Department has collected information on the numbers of fire personnel, the number of reported fires, and the number of reported fire deaths in major cities of the world [32]. A compilation of this fire loss data for foreign cities is presented in Table 5-1. Tokyo Fire Department data for United States cities are shown in Appendix Table A-7.

There is no way of knowing from the brief reports received by the Tokyo Fire Department how accurate the reported data may be. It should be noted that the world cities are not a random sample of all world cities. For instance, four of the 14 largest cities are in Asia and none of the smaller cities are from that continent. However, the average rates of fires per 10,000 population and fire deaths per million population shown in Table 5-1 mirror national experience presented in earlier sections.

Figures 5-1 and 5-2 plot the average rates for non-United States cities in the Tokyo survey versus estimated average rates for all United States cities of comparable size with the latter rates having been prepared by FEMA [21]. Separate averages are provided for cities of over 1,000,000 people, 500,000 to 1,000,000 people, and 250,000 to 500,000 people. For all three sizes of cities, and both fire incidence and fire deaths, the values in Table 5-1 and the graphical portrayal in Figures 5-1 and 5-2 confirm the relatively poor standing of the United States. Particularly in the largest cities, the reported per capita fire incidence and fire fatality rate is many times that of the world cities considered.

The "Comparable United States Average Rates" in Table 5-1 (labeled

TABLE 5-1

WORLD CITY FIRE LOSSES

City	Protected Population (in 1,000's)	Fire Fighting Personnel	Number of Reported Fires	Number of Reported Fire Deaths	Fires Per 10,000 Population	Deaths Per Million Population
Over 1,000,000 People						
Tokyo	11,232	17,989	6,906	139	6	12
New Delhi	6,900	946	3,506	62	5	9
London	6,894	7,891	46,064	195	67	28
Hong Kong	5,100	5,174	13,213	36	26	7
Greater Manchester	2,675	2,684	25,571	77	96	29
Singapore	2,414	984	4,705	6	19	2
Johannesburg	2,263	522	1,703	13	8	6
Berlin	2,004	3,295	7,000	45	35	22
Hamburg	1,664	5,019	8,040	13	48	8
Essex	1,500	1,481	5,979	7	40	5
Kent	1,449	1,919	12,178	23	84	16
Lancashire	1,388	1,493	9,892	37	71	27
Brussels	1,100	876	2,157	9	20	8
Montreal	1,070	2,301	5,802	27	54	25
Average of City Rates					41.4	14.6
Comparable United States Average Rate					150.5	40.9
United States Five Year Average Death Rate						39.6
500,000 to 1,000,000 People						
Koln	979	850	2,963	2	30	2
Hertfordshire	955	921	4,079	7	43	7
Cape Town	945	309	2,020	18	21	19
Lothian and Borders	930	1,060	6,812	14	73	15
Avon	917	996	4,598	8	50	9
Brisbane	717	751	3,296	9	46	13
Amsterdam	712	827	3,227	4	45	6
Stockholm	647	672	5,956	11	92	17
Frankfort	632	883	1,972	7	31	11
Rotterdam	579	705	3,092	16	53	28
Bremen	556	620	1,460	4	26	7
Edmonton	506	961	3,794	6	75	12
Average of City Rates					48.8	12.2
Comparable United States Average Rate					142.5	31.5
United States Fire Year Average Death Rate						34.1
250,000 to 500,000 People						
Copenhagen	499	782	2,048	-	41	-
Helsinki	484	477	1,373	5	28	10
Oslo	450	529	1,399	11	31	24
Vancouver	413	826	3,235	8	78	19
Hamilton	307	431	5,906	3	192	10
Ottawa	302	522	1,566	7	52	23
Bonn	287	301	687	4	24	14
Wellington	145	330	930	2	64	14
Average of City Rates					63.8	16.3
Comparable United States Average Rate					137.0	35.2
United States Five Year Average Death Rate						35.4

Notes: All data are for 1980 and are as reported in a compilation prepared annually by the Tokyo Fire Department [32]. Deaths pertain to citizen population members only.

Comparable United States average rates are based on samples taken in 1979 and 1980. The number of cities in each sample, by given population category is 5, 18 and 34. Source [21].

The United States five year average death rates are based on death certificate reports for the years 1974-78. Source [21].

Protected population is not necessarily contiguous with what is commonly considered the "City".

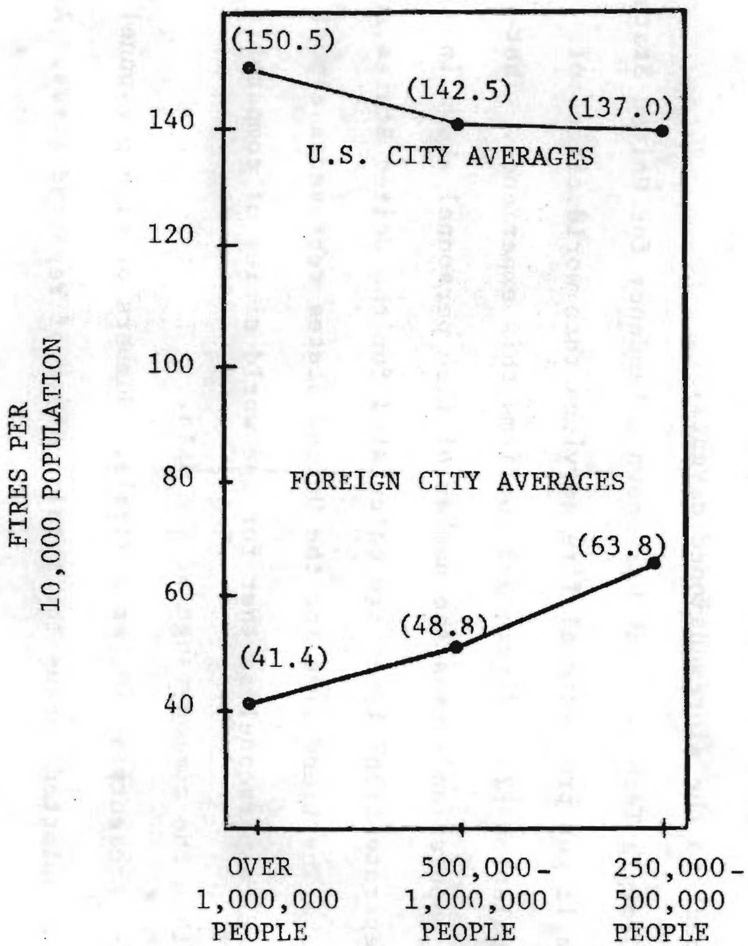

FIGURE 5-1. WORLD CITIES FIRE RATE PER 10,000 PERSONS VS. UNITED STATES CITIES

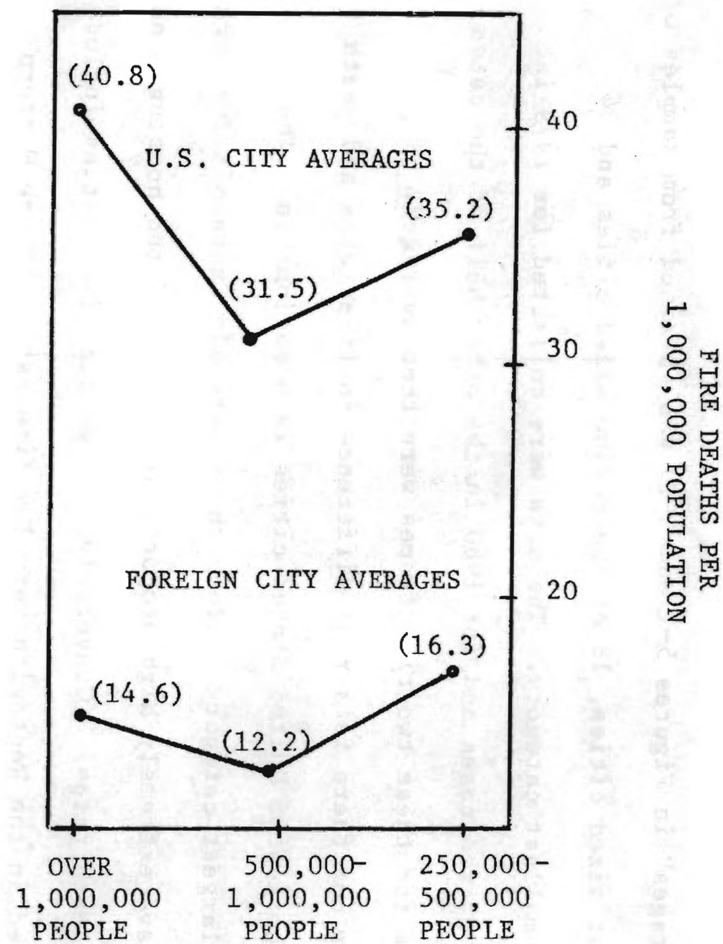

FIGURE 5-2. WORLD CITIES DEATH RATE PER 1,000,000 PERSONS VS. UNITED STATES CITIES

Notes: U.S. City Averages are from the Federal Emergency Management Agency estimates [21].

Other data are as reported in a compilation prepared annually by the Tokyo Fire Department [32].

"U.S. City Averages" in Figures 5-1 and 5-2) was obtained from samples of 6 of the largest sized cities, 18 of the medium sized cities and 34 cities in the smallest category. The data were collected for 1979 in about one-half of the cases and for 1980 in the other half of the cases [21]. The data for these two time frames were then averaged.

Whether or not there is a real difference in fire rates and death rates for categories of United States cities is questionable. The 6 cities in the largest category include three very old Eastern/Midwestern cities which have extremely high proportions of dilapidated housing (and high fire and death rates). Conversely, the medium sized cities include a number located in the West with very low fire rates. These Western cities are much newer than the Eastern/Midwestern cities.

Thus, there are questions about the selection bias of both the foreign and the United States cities. Whether there are true differences between categories of cities, according to population, can not be answered unequivocally by this analysis. Reader inferences should be made with respect to the aforementioned caveats.

Earlier Georgia Tech research has shown a tendency for United States cities to have larger professional fire services than world cities of comparable population [2]. Figure 5-3 confirms this experience. That figure graphs population versus the number of fire personnel shown in Table 5-1. Separate trend lines are calculated for the United States and foreign cities. The trend line for the United States represents almost twice as many fire personnel as that for the world cities of comparable population within the common range of the data.

Figure 5-4 presents a similar analysis. Numbers of fire personnel in Table 5-1 are plotted versus the total numbers of reported fires. As

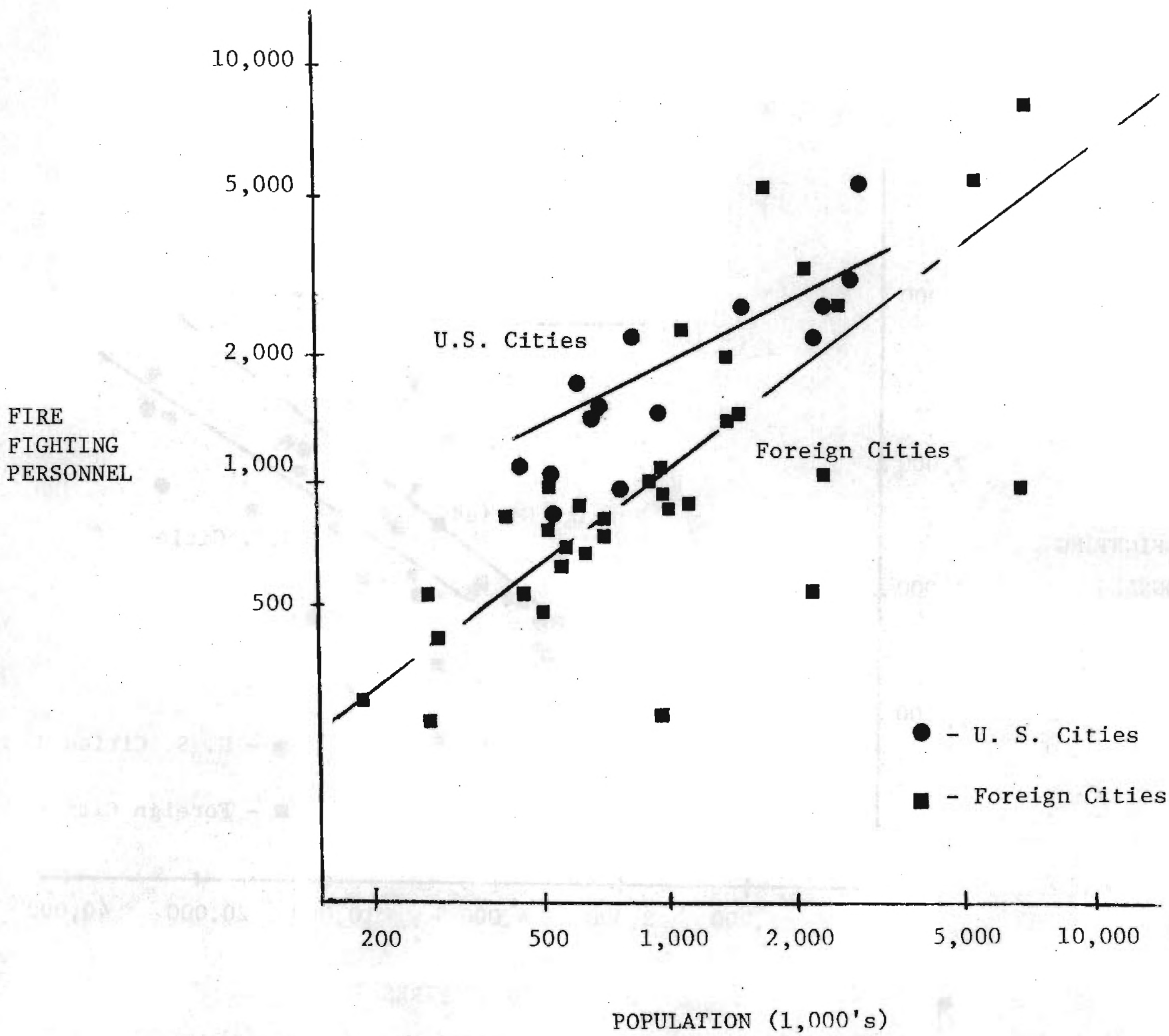

FIGURE 5-3. POPULATION VS. TOTAL FIRE PERSONNEL FOR WORLD CITIES

Notes: Data are as reported in a compilation prepared annually by the Tokyo Fire Department [32]. Trend lines are computed by Georgia Tech.

Fire Fighting Personnel are for 1980 - unless indicated otherwise as shown in Table 5-1.

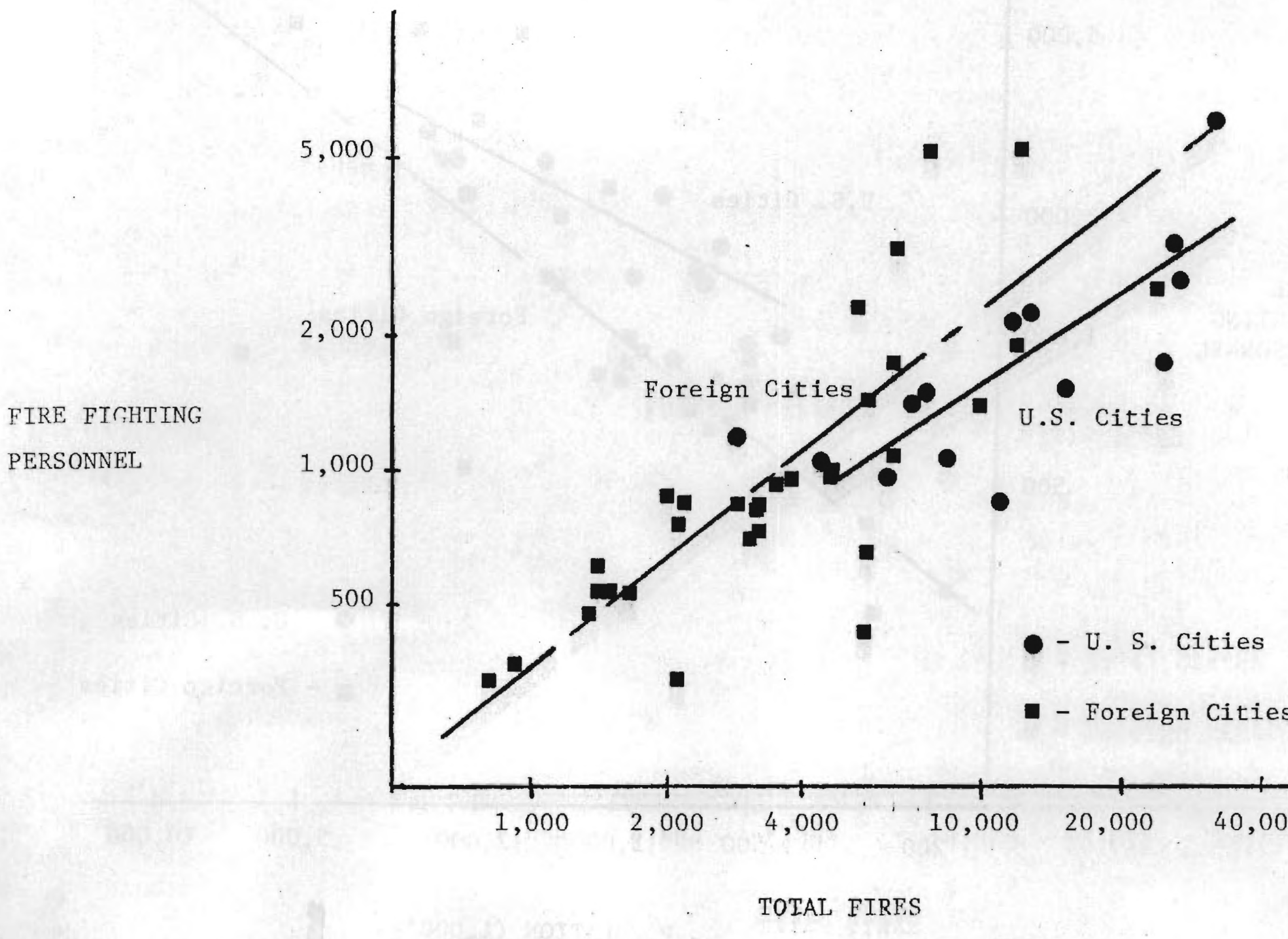

FIGURE 5-4. TOTAL FIRES VS. TOTAL FIRE PERSONNEL FOR WORLD CITIES

Notes: Data are as reported in a compilation prepared annually by the Tokyo Fire Department [32]. Trend lines are computed by Georgia Tech.

Fire Fighting Personnel and Total Fires are for 1980 unless indicated otherwise as shown in Table 5-1.

with the earlier figure, separate trend lines are computed for the United States cities and foreign cities.

The latter trend lines show that fire personnel per fire in foreign cities is at least 25% higher than the comparable value for the United States within the common range of the data. Thus, much of the variation in per capita fire peronnel shown in Figure 5-3 is apparently connected with variations in fire incidence. In the light of general findings throughout this report of relatively high fire incidence in the United States, these results suggest that the greater number of fire personnel in the United States is primarily a reflection of the greater fire problem. However, it is possible to argue for a reverse association. Greater availability of fire service in the United States cities may lead to more frequent calling of the fire service for small fires and thus greater reporting of such minor incidents.

References

1. Assemblée Pléniére des Sociétés d'Assurances, Correspondence to Jerry Banks, January, 1982.

2. Banks, Jerry and Rardin, R.L., "Selected International Comparisons of Fire Losses, 1975-78, Determinants of International Differences in Reported Fire Loss: Revised Edition," December, 1980.

3. Belgium Ministere de L'Interieur, "Interventions des Services de Secours," published annually.

4. The Board of Fire Commissioners of New South Wales, "Fire Statistics: New South Wales," published annually.

5. British Fire Protection Association (1976), "U.K. Fire Damage Compared with Those of Other Countries, 1970-74," Fire Prevention, No. 113, p. 39.

6. British Home Office, "United Kingdom Fire Statistics," published annually.

7. British Insurance Association, "Insurance Facts and Figures," published annually.

8. (Trade Report), Bundesaufsichtamtes für vas Veisicherungswesen, Berlin, 1980.

9. Danmarks Statistik, "Brandskader (year)," published annually.

10. Die Osterreichischen Brandverhutungsstellen, "Die Branschaden in Osterrich," published annually.

11. Dominion Fire Commission, "Fire Losses in Canada," published annually.

12. Dutch Centraal Bureau voor de Statistick, "Statistiek der Branden," published annually.

13. Europa Handbook, Europa Publications Limited, published annually.

14. French Ministere de L'Interieur, "Interventions des Sapeurs-Pampiers," published annually.

15. French, R.A., Correspondence with Jerry Banks, February, 1982.

16. International Monetary Fund, "International Financial Statistics," published monthly with annual data in May issue.

17. Ireland Department of the Environment, "Fire Statistics," published annually.

18. Japan Fire Protection Association, White Book on Fire Services in Japan, published annually.

19. Keough, J.J., Correspondence with Jerry Banks, dated November, 1979

20. Motor Vehicle Manufacturers Association of the United States, Inc., "Motor Vehicle Facts and Figures," published annually.

21. National Fire Data Center, "Fire in the United States," National Fire Prevention and Control Administration (now published by the Federal Emergency Management Agency).

22. National Fire Protection Association, Fire Protection Handbook, published annually.

23. New Zealand Fire Service Commission, "Report of the New Zealand Fire Service Commission for the year ended 31 March, 1981."

24. Norges Brannkasse, Skadeforsikringsselskapenes Forening, "Branner i Norge," published annually.

25. Rardin, R.L. and Morris Mitzner, "Final Summary Report, Determinants of International Differences in Reported Fire Loss: Preliminary Investigation," June, 1977.

26. Rardin, R.L. and Morris Mitzner, "Final Technical Report, Determinants of International Differences in Reported Fire Loss: Preliminary Investigation," June, 1977.

27. Rardin, R.L. and Morris Mitzner, "Report on Fire Data Collection and Presentation, Determinants of International Differences in Reported Fire Loss: Preliminary Investigation," June, 1978.

28. Rardin, R.L. and Morris Mitzner,"Selected International Comparisons of Fire Losses, Determinants of International Differences in Reported Fire Loss: Preliminary Investigation," June, 1978.

29. Rydning, A., Correspondence to Jerry Banks, dated February, 1981.

30. SBF Svenska Brandforsvarsforeningen, "SBFs verksomhet, (year)," published annually.

31. Swiss Association of Public Insurers, "Brandstatistik (year)," published annually.

32. Tokyo Fire Department, "Statistics on Fire Services in the World," published annually.

33. Tovey, Henry, Memorandum, subject: Draft ISO Standard Fire Data System, July 3, 1979.

34. Toyoshima, Riemon (1971),"Conditions of Fire Losses in Japan," paper presented to the National Fire Protection Association.

35. U.N. Statistics Office, "Monthly Bulletin," published monthly.

36. United Nation's Statistical Office (serial-g), Statistical Yearbook U.N. Publishing Service, published annually.

37. U.S. Department of Commerce, Bureau of Census, Statistical Abstract of the U.S., published annually.

38. Wilmot, R.T.D., "European Fire Cost: The Wasteful Statistical Gap," (2nd Edition), Association de Geneve, April, 1979.

39. World Health Organization (serial), Who Statistics Annual: Vital Statistics and Causes of Death, World Health Organization, Geneva, published annually.

SELECTED INTERNATIONAL COMPARISONS OF FIRE LOSS

1979–1980

APPENDIX

By

Jerry Banks

GEORGIA INSTITUTE OF TECHNOLOGY

Atlanta, Georgia 30332

With the Support of the
Federal Emergency Management Agency
Grant No. EMW–6–0655

September 1982

TABLE OF CONTENTS

LIST OF TABLES

APPENDIX A

SUPPORTING TABLES

TABLE A-1

POPULATION DATA

		0–4	5–14	15–24	25–44	45–64	65+	TOTAL
AUSTRALIA	MALE	611,074	1,309,248	1,247,251	1,951,548	1,401,868	534,249	7,055,238
	FEMALE	581,166	1,241,760	1,204,763	1,864,554	1,388,162	738,468	7,018,873
	TOTAL	1,192,240	2,551,008	2,452,014	3,816,102	2,790,030	1,272,717	14,074,111
AUSTRIA	MALE	246,708	630,859	564,417	971,626	708,665	420,147	3,542,422
	FEMALE	235,134	602,761	544,608	955,065	916,929	716,076	3,970,573
	TOTAL	481,842	1,233,620	1,109,025	1,926,691	1,625,594	1,136,223	7,512,995
BELGIUM	MALE	325,883	769,184	790,357	1,292,805	1,076,466	552,155	4,806,850
	FEMALE	309,136	736,037	754,296	1,250,853	1,139,995	821,060	5,011,377
	TOTAL	635,019	1,505,221	1,544,653	2,543,658	2,216,461	1,373,215	9,818,227
CANADA	MALE	894,700	2,082,000	2,309,400	3,220,500	2,181,900	900,400	11,588,900
	FEMALE	850,600	1,983,800	2,257,500	3,168,900	2,272,900	1,168,600	11,702,300
	TOTAL	1,745,300	4,065,800	4,566,900	6,389,400	4,454,800	2,069,000	23,291,200
DENMARK	MALE	182,842	399,009	380,821	704,877	546,296	295,990	2,509,835
	FEMALE	175,052	379,947	361,925	679,366	571,888	394,583	2,562,761
	TOTAL	357,894	778,956	742,746	1,384,243	1,118,184	690,573	5,072,596
FINLAND	MALE	156,579	366,365	412,023	695,410	463,806	190,076	2,284,259
	FEMALE	148,921	351,939	394,748	666,771	552,689	326,348	2,441,416
	TOTAL	305,500	718,304	806,771	1,362,181	1,016,495	516,424	4,725,675
FRANCE	MALE	1,942,014	4,333,819	4,301,514	7,233,345	5,376,141	2,865,557	26,052,390
	FEMALE	1,852,322	4,145,552	4,154,274	6,826,606	5,674,903	4,476,953	27,130,610
	TOTAL	3,794,336	8,479,371	8,455,788	14,059,951	11,051,044	7,342,510	53,183,000
GERMANY	MALE	1,545,100	4,826,500	4,623,200	8,906,900	5,940,900	3,400,500	29,243,100
	FEMALE	1,477,900	4,599,300	4,437,700	8,364,900	7,457,800	5,819,400	32,157,000
	TOTAL	3,023,000	9,425,800	9,060,900	17,271,800	13,398,700	9,219,900	61,400,100
IRELAND	MALE	173,700	336,600	279,900	355,100	297,400	156,900	1,599,600
	FEMALE	165,000	321,900	269,200	344,600	302,400	189,600	1,592,700
	TOTAL	338,700	658,500	549,100	699,700	599,800	346,500	3,192,300
JAPAN	MALE	4,929,468	9,248,057	8,233,933	18,673,939	11,010,380	4,102,893	56,198,670
	FEMALE	4,675,397	8,796,569	7,996,656	18,607,012	12,422,279	5,457,677	57,955,590
	TOTAL	9,604,865	18,044,626	16,230,589	37,280,951	23,432,659	9,560,570	114,154,260
NETHERLANDS	MALE	476,603	1,236,075	1,203,154	1,995,027	1,337,414	641,109	6,889,382
	FEMALE	454,581	1,180,012	1,155,052	1,866,394	1,420,244	890,520	6,966,803
	TOTAL	931,184	2,416,087	2,358,206	3,861,421	2,757,658	1,531,629	13,856,185
NEW ZEALAND	MALE	143,520	319,950	290,320	400,210	287,030	121,060	1,562,090
	FEMALE	137,440	305,590	278,390	391,970	289,100	163,150	1,565,640
	TOTAL	280,960	625,540	568,710	792,180	576,130	284,210	3,127,730
NORWAY	MALE	146,938	334,866	314,539	516,999	449,129	244,038	2,006,509
	FEMALE	140,596	317,764	300,031	490,305	461,101	326,899	2,036,696
	TOTAL	287,534	652,630	614,570	1,007,304	910,230	570,937	4,043,205
SWEDEN	MALE	278,238	591,591	559,381	1,135,118	968,040	554,475	4,086,843
	FEMALE	264,611	561,775	534,455	1,079,209	987,576	707,612	4,135,238
	TOTAL	542,849	1,153,366	1,093,836	2,214,327	1,955,616	1,262,087	8,222,081
SWITZERLAND	MALE	190,300	485,700	480,500	919,500	650,400	337,900	3,064,300
	FEMALE	180,900	463,500	475,000	902,100	703,400	502,800	3,227,700
	TOTAL	371,200	949,200	955,500	1,821,600	1,353,800	840,700	6,292,000
UNITED KINGDOM	MALE	1,912,386	4,661,289	4,158,237	7,138,627	6,266,207	3,078,270	27,215,016
	FEMALE	1,802,336	4,422,148	3,970,817	6,990,048	6,659,627	4,857,059	28,702,035
	TOTAL	3,714,722	9,083,437	8,129,054	14,128,675	12,925,834	7,935,329	55,917,051
UNITED STATES	MALE	7,790,000	18,550,000	20,617,000	27,746,000	20,969,000	9,569,000	105,241,000
	FEMALE	7,446,000	17,820,000	20,369,000	28,725,000	22,809,000	13,925,000	111,094,000
	TOTAL	15,236,000	36,370,000	40,986,000	56,471,000	43,778,000	23,494,000	226,335,000

Note: Population data taken from the Demographic Yearbook: 1978 of the United Nations [36].

TABLE A-2

COMPARISON OF FIRE LOSS INDICES FOR 1965-67

COUNTRIES	BUILDING FIRES/1,000 PERSONS	$ BUILDING FIRE LOSS PER CAPITA	BUILDING FIRE LOSS AS % OF GNP	FIRE DEATHS/ 1,000,000 PERSONS	$ BUILDING FIRE LOSS/ FIRE (1,000'S)	FIRE DEATHS/ 1,000 BUILDING FIRE
AUSTRALIA	-	-	-	25 66%	-	-
AUSTRIA	1.6 33%	3.2 21%	.12 60%	10 26%	2.0 67%	6.0 77%
BELGIUM	1.0 21%	-	-	-	-	-
CANADA	3.2 67%	13.1 87%	.24 120%	36 95%	4.0 133%	11.0 141%
DENMARK	2.0 42%	13.6 91%	.24 120%	10 26%	7.0 233%	5.2 67%
FRANCE	0.4 8%	11.0 73%	.20 100%	3 8%	27.5 917%	7.5 96%
GERMANY (F.R.)	-	4.7 31%	.13 65%	7 18%	-	-
JAPAN	0.3 6%	3.1 21%	.13 65%	19 50%	10.2 340%	62.6 803%
NETHERLANDS	0.6 12%	7.2 48%	.18 90%	8 21%	13.0 433%	14.3 183%
NORWAY	2.4 50%	12.9 86%	.29 145%	15 39%	5.5 183%	6.3 81%
UNITED KINGDOM	1.6 33%	11.7 78%	.19 95%	14 37%	7.0 233%	9.3 119%
UNITED STATES	4.8 100%	15.0 100%	.20 100%	38 100%	3.0 100%	7.8 100%

Note: Data are adjusted from Georgia Tech report Determinants of International Differences in Reported Fire Loss dated June, 1977 [25]. All monetary data are expressed in 1977 U.S. dollars.

TABLE A-3

COMPARISON OF FIRE LOSS INDICES FOR 1972-74

COUNTRIES	BUILDING FIRES/1,000 PERSONS	$ BUILDING FIRE LOSS PER CAPITA	BUILDING FIRE LOSS AS % OF GNP	FIRE DEATHS/ 1,000,000 PERSONS	$ BUILDING FIRE LOSS/ FIRE (1,000'S)	FIRE DEATHS/ 1,000 BUILDING FIRE
AUSTRALIA	–	–	–	15 48%	–	–
AUSTRIA	2.0 35%	5.8 33%	.12 57%	10 32%	3.1 100%	5.0 93%
BELGIUM	1.2 21%	–	–	13 42%	–	10.8 200%
CANADA	3.5 61%	19.4 110%	.24 114%	34 110%	5.8 187%	9.7 180%
DENMARK	3.4 60%	18.5 105%	.22 105%	12 39%	6.0 194%	3.5 65%
FRANCE	0.8 14%	14.5 82%	.19 90%	15 48%	18.1 580%	18.8 348%
GERMANY (F.R.)	–	11.3 64%	.16 76%	9 29%	–	–
JAPAN	0.4 7%	4.4 25%	.07 33%	16 52%	12.0 387%	40.0 741%
NETHERLANDS	0.8 14%	10.8 61%	.17 81%	6 19%	14.0 452%	7.5 139%
NORWAY	9.3 163%	24.0 136%	.35 167%	13 42%	2.5 81%	1.4 26%
UNITED KINGDOM	2.5 43%	15.3 86%	.24 114%	17 55%	6.2 200%	6.8 126%
UNITED STATES	5.7 100%	17.7 100%	.21 100%	31 100%	3.1 100%	5.4 100%

Note: Data are adjusted from Georgia Tech report Determinants of International Differences in Reported Fire Loss, dated June, 1977 [25]. All monetary data are expressed in 1977 U.S. dollars.

TABLE A-4

COMPARISON OF FIRE LOSS INDICES FOR 1976-78

COUNTRIES	BUILDING FIRES/1,000 PERSONS	$ BUILDING FIRE LOSS PER CAPITA	BUILDING FIRE LOSS AS % OF GNP	FIRE DEATHS/ 1,000,000 PERSONS	BUILDING FIRE LOSS/ FIRE ($1,000'S)	FIRE DEATHS/ 1,000 BUILDING FIRES
Australia 1977	1.2 25%	- -	- -	11.6 34%	- -	9.6 133%
Austria 1977, 78	2.4 50%	9.6 49%	.15 65%	9.2 27%	4.0 95%	3.9 54%
Belgium 1977	1.2 25%	- -	- -	12.6 37%	- -	7.9 110%
Canada 1977	3.2 67%	23.6 120%	.27 117%	32.1 94%	7.3 174%	9.9 138%
Denmark 1976, 77, 78	3.3 69%	25.6 131%	.26 113%	11.6 34%	7.6 181%	3.5 49%
France 1976, 77	1.5 31%	22.2 113%	.26 113%	14.9 44%	14.6 348%	10.0 139%
Germany 1977, 78	- -	13.3 68%	.16 70%	8.9 26%	- -	- -
Ireland 1976, 77, 78	6.5 135%	9.8 50%	.16 70%	24.0 70%	1.5 36%	3.7 51%
Japan 1977	0.3 6%	4.0 20%	.07 30%	14.1 41%	11.6 276%	40.6 564%
Netherlands 1976, 77	1.0 21%	13.3 68%	.16 70%	5.3 15%	12.9 307%	5.2 72%
Norway 1976, 77	3.9 82%	36.4 186%	.42 183%	14.6 43%	9.5 226%	3.8 53%
United Kingdom 1976, 77	1.7 35%	8.9 45%	.20 87%	15.4 45%	5.2 124%	9.0 125%
United States 1977, 78	4.8 100%	19.6 100%	.23 100%	34.2 100%	4.2 100%	7.2 100%

Notes: Losses are expressed in 1977 U.S. dollars.

Death values from WHO Statistics Annual: Vital Statistics and Causes of Death [39] and reflect an average for 1975-77.

Percentages reflect the rates formed by comparing the fire loss index value for the country under consideration to the same fire loss index for the United States.

TABLE A-5

DEATH RATES BY AGE AND SEX, 1972-74

		0-4	5-14	15-24	25-44	45-64	65+	TOTAL
AUSTRALIA	MALE	22	5	7	9	29	74	18
	FEMALE	19	2	3	5	17	44	12
	TOTAL	21	3	5	7	23	57	15
AUSTRIA	MALE	13	1	6	10	14	52	14
	FEMALE	9	5	1	1	7	26	7
	TOTAL	10	3	3	5	10	32	10
BELGIUM	MALE	33	14	10	13	11	36	16
	FEMALE	17	4	4	4	12	28	13
	TOTAL	25	9	7	8	12	31	13
CANADA	MALE	78	21	23	27	58	131	43
	FEMALE	58	17	12	13	33	60	26
	TOTAL	68	19	24	34	52	125	34
DENMARK	MALE	13	0	12	6	13	52	14
	FEMALE	8	6	4	4	9	41	11
	TOTAL	11	3	8	5	11	42	12
FINLAND	MALE	6	6	25	36	34	67	31
	FEMALE	16	2	1	9	12	20	10
	TOTAL	11	4	4	22	27	31	20
FRANCE	MALE	15	6	9	14	20	51	17
	FEMALE	21	4	3	5	8	42	13
	TOTAL	21	5	6	9	16	45	15
GERMANY (F.R.)	MALE	12	3	8	8	12	35	11
	FEMALE	10	2	2	3	8	24	8
	TOTAL	11	2	4	6	10	28	9
IRELAND	MALE	24	10	5	9	17	131	24
	FEMALE	31	13	10	8	22	122	28
	TOTAL	28	12	7	8	19	126	26
JAPAN	MALE	18	6	7	9	20	136	20
	FEMALE	16	5	5	6	8	84	14
	TOTAL	17	6	6	7	14	106	16
NETHERLANDS	MALE	9	4	6	5	5	26	7
	FEMALE	5	2	3	2	4	10	5
	TOTAL	7	3	4	4	5	17	6
NEW ZEALAND	MALE	6	4	10	12	27	67	16
	FEMALE	11	3	3	2	11	51	9
	TOTAL	9	4	6	7	19	57	13
NORWAY	MALE	37	3	8	11	17	44	18
	FEMALE	13	9	2	2	4	26	8
	TOTAL	25	6	5.	7	11	34	13
SWEDEN	MALE	12	4	6	13	30	50	19
	FEMALE	4	4	2	4	9	23	8
	TOTAL	8	4	4	9	19	35	14
SWITZERLAND	MALE	6	3	3	4	8	28	6
	FEMALE	3	1	0	1	7	16	5
	TOTAL	4	2	1	2	7	21	6
UNITED KINGDOM	MALE	31	6	6	9	13	59	17
	FEMALE	30	5	4	5	9	67	18
	TOTAL	31	6	5	7	13	64	17
UNITED STATES	MALE	55	15	18	27	42	117	38
	FEMALE	44	15	8	11	27	69	22
	TOTAL	49	11	13	19	39	89	31

Notes: Death rates are per million population in the age category indicated.

Death data are from WHO Statistics Annual: Vital Statistics and Causes of Death [39] and reflect an average for the time period.

Population data are from the Statistical Yearbook, published by the United Nations [36].

TABLE A-6

DEATH RATES BY AGE AND SEX, 1975-77

		0-4	5-14	15-24	25-44	45-64	65+	TOTAL
AUSTRALIA	MALE	44	14	22	20	30	50	26
	FEMALE	26	5	4	4	10	30	9
	TOTAL	35	10	13	12	20	38	18
AUSTRIA	MALE	7	1	3	6	12	37	10
	FEMALE	6	1	1	3	5	33	8
	TOTAL	6	1	2	4	8	36	9
BELGIUM	MALE	53	9	12	8	11	26	15
	FEMALE	16	3	8	6	11	24	11
	TOTAL	35	6	10	7	11	25	13
CANADA	MALE	44	19	24	34	52	125	40
	FEMALE	48	17	15	14	26	60	24
	TOTAL	46	18	19	24	39	87	32
DENMARK	MALE	9	5	14	12	12	37	14
	FEMALE	2	1	3	5	9	34	9
	TOTAL	6	3	8	8	11	35	12
FINLAND	MALE	6	3	10	25	59	71	28
	FEMALE	0	3	5	2	9	32	8
	TOTAL	3	3	7	14	32	46	17
FRANCE	MALE	22	4	10	13	19	48	17
	FEMALE	20	4	3	6	8	42	13
	TOTAL	21	4	7	9	13	44	15
GERMANY (F.R.)	MALE	16	3	6	9	12	31	12
	FEMALE	10	2	3	3	8	18	7
	TOTAL	13	3	4	6	10	23	9
IRELAND	MALE	53	3	7	5	17	103	22
	FEMALE	25	3	4	9	6	167	27
	TOTAL	39	3	6	7	11	133	24
JAPAN	MALE	18	6	6	8	18	115	17
	FEMALE	14	4	4	4	6	66	11
	TOTAL	16	5	5	5	12	87	14
NETHERLANDS	MALE	13	2	3	4	6	27	7
	FEMALE	8	2	1	3	4	10	4
	TOTAL	11	2	2	3	5	17	5
NEW ZEALAND	MALE	10	2	5	6	26	55	13
	FEMALE	17	11	0	6	10	38	13
	TOTAL	13	7	3	6	18	57	13
NORWAY	MALE	26	0	7	16	29	62	22
	FEMALE	9	3	3	2	7	28	9
	TOTAL	18	1	6	10	18	43	15
SWEDEN	MALE	19	5	13	17	32	49	21
	FEMALE	9	3	4	5	10	25	9
	TOTAL	14	5	8	11	21	31	15
SWITZERLAND	MALE	1	5	1	4	6	25	7
	FEMALE	3	5	3	1	6	14	5
	TOTAL	2	5	2	3	6	19	6
UNITED KINGDOM	MALE	21	6	5	7	14	55	15
	FEMALE	23	5	5	5	11	57	16
	TOTAL	22	6	5	6	12	56	15
UNITED STATES	MALE	53	18	18	26	45	104	36
	FEMALE	42	14	9	10	23	59	22
	TOTAL	45	16	14	17	36	78	29

Notes: Death rates are per million population in the age category indicated.

Death data are from <u>WHO Statistics Annual: Vital Statistics and Causes of Death</u> [39] and reflect an average for the time period.

Population data are from the Statistical Yearbook published by the United Nations [36].

TABLE A-7

U.S. CITIES FIRE LOSSESS

City	Protected Population (in 1,000's)	Fire Fighting Personnel	Number of Reported Fires	Number of Reported Fire Deaths	Fires per 10,000 Population	Deaths Per Million Population
Over 1,000,000 people						
Chicago	3,005	5,567	31,718	142	106	47
Los Angeles City	2,091	3,512	26,797	31	92	11
Houston	2,400	3,018	12,507	41	52	17
Los Angeles County	2,269	2,385	13,211	24	58	11
Philadelphia	1,688	2,863	27,348	85	162	50
500,000 to 100,000 people						
Dallas	901	1,601	15,951	24	177	27
Honolulu	797	971	6,701	13	84	16
Baltimore	787	2,196	12,390	51	157	65
San Francisco	675	1,633	8,080	28	120	41
Washington, D.C.	650	1,498	7,654	28	118	43
Boston	583	1,799	26,756	17	459	29
St. Louis	508	870	11,033	24	217	47
Seattle	502	1,070	8,779	24	175	48
250,000 to 500,000 people						
Pittsburgh	450	1,095	4,416	23	98	51

Notes: All data are for 1980 and are as reported in a compilation prepared annually by the Tokyo Fire Department [32].

APPENDIX B

DETAILS OF CALCULATIONS

In preparing the various tables of this report, numerous regroupings and interpolations were necessary to make results for other countries conform to United States reports [21]. This appendix provides details omitted in the main text on the calcuations which were undertaken in preparing each table.

B.1 Derivation of Values in Table 2-1

Table 2-1, Comparison of Fire Loss Indices for 1978-1979, requires the following data elements, if available, for all countries:

- Building Fires
- Population
- Building Fire Loss (converted to 1979 US $)
- GNP
- Fire Deaths

Population data are from the Demographic Yearbook: 1978, of the United Nations [36]. Specifically, Table 7 was used since it gives population values by sex, a statistic useful elsewhere in this updated fire report. Most of the estimates in the UN publication were for 1976.

GNP data was obtained mainly from publications of the U.S. Department of Commerce [37]. The Europa Handbook was used to obtain an estimate of the 1979 GNP for Austria [13]. The 1980 GNP of Austria was estimated from the increase in the GNP over the 1979 value. Death data came from WHO [39] under the category, "Accidents Due to Fires and Flames." These data were taken from the latest year available, which was usually 1977 or 1978, but ranged from 1975-78.

Building fire losses for the various nations, from which such data were obtained, were converted to constant 1979 US dollars. Such conversions may have required several pieces of international monetary data and several operations. The data elements are the exchange rates for 1979 and 1980 as well as consumer price indexes for that time period. The exchange rates are from International Financial Statistics, mentioned above. Consumer price information is from the U.N. Monthly Bulletin for December 1980 [35].

The data elements mentioned above are used to compute the columnar values in Table 2-1 in a straightforward manner. In those instances which have two or more years of fire loss data, the annual value is computed, then an average is formed of the annual values. This method applies to the columns indicated as follows:

- $ Building Fire Loss Per Capita
- Building Fire Loss (as % of GNP)
- Building Fire Loss/Fire ($1,000's).

For example, if monetary fire loss data are available for 1979 and 1980, the loss data were first converted to U.S. dollars (1979). Then, the dollar building fire loss per capita is computed for each year. These two values are then averaged for the two years, and the resultant enters Table 2-1.

In the paragraphs which follow, the calculations for a) building fires and b) building fire loss, are presented. If the data is unavailable, that letter is skipped.

B.1.1 Australia

Fire for New South Wales were obtained from statistics provided by the Experimental Building Station [4]. "As New South Wales (NSW) is fairly representative of Autralia generally, it is reasonable to use the population ratio as a factor to obtain a national picture" [19]. In 1979, the population of NSW was 5,075,800 and that of Australia was 14,417,200. Therefore, the multiple was 2.84.

a) Building Fires. Table 16 of the compiled statistics indicates that there were 6,172 building fires in NSW in 1979. Thus, the estimate for Australia is

$$\text{Estimated Building Fires} = 2.84 \times 6{,}172 = 17{,}528.$$

B.1.2 Austria

Data was obtained from the document translated as "The Fire Damage in Austria in 1979 (1980)", prepared by the Austrian Fire Prevention Agency [10]. As mentioned above, calculations for the fire loss in Austria in 1979 U.S. dollars will be fully depicted as a model for other conversions that were made.

a) Building Fires. Table 3 (untitled) in the 1980 document [10] contains incident measures for both 1979 and 1980. An average of the values for 1979-80 was determined as follows:

$$\text{Average Building Fires (Preliminary)} = \frac{22{,}442 + 22{,}053}{2} = 22{,}247.5.$$

These losses include a category called "Landwirtschaft," which was translated as "agriculture and agribusiness." As in the previous investigation [2], it was estimated that one-half of such fires were in buildings and the remainder in open space. The average was as follows:

$$\text{Average Landwirtschaft} = \frac{2,431 + 2,345}{2} = 2,388.$$

One-half of Landwirtschaft was then determined as 1,194. The incidents in Table 3 were broken down into major fires with significant losses, and those which were not significant. The average of total fires with significant loss was calculated as follows:

$$\text{Average Significant} = \frac{11,002 + 11,081}{2} = 11,041.5.$$

The proportion of these fires which were Landwirtschaft was then determined as follows:

$$\text{Proportion Landwirtschaft} = \frac{1,194}{11,041.5} = .108.$$

This proportion was increased to 0.125 since it agreed with perceptions of the researchers concerning the measure based on prior studies at Georgia Tech [2,28]. The complement of this last proportion, or 0.875, was applied to the building fire average to obtain the estimate as follows:

$$\text{Average Building Fires Estimate} = .875 \times 22,247.5 = 19,467.$$

b) <u>Fire Loss.</u> Damage estimates were also given in Table 3. The 0.875 factor described above was verified for losses (all in 1,000's of schillings) in the following manner:

$$\text{Average Landwirtschaft Loss} = \frac{397,783 + 396,242}{2} = 397,012.5.$$

One-half of this loss is attributed to buildings, or

$$\tfrac{1}{2} \text{ of Average Landwirtschaft} = \frac{397,012.5}{2} = 198,506.2.$$

The average significant losses for the two years was calculated as follows:

$$\text{Average Total Significant Fire Loss} = \frac{2,247,153 + 1,292,964}{2} = 1,770,058.5.$$

The proportion of non-building fire loss is then

$$\text{Proportion Non-Building Fire Loss} = \frac{198,506.2}{1,770,058.5} = .112.$$

The complement of .112 is .888 which verifies the use of the proportion 0.875 (described in (a) above) as a factor. Losses for 1979 and 1980 were then calculated as follows:

$$\text{Loss for } 1979 = .875 \times 2,253,306 = 1,971,643 \times 10^3 \text{ shillings}$$

$$\text{Loss for } 1980 = .875 \times 1,299,610 = 1,137,159 \times 10^3 \text{ shillings.}$$

Now, these losses must be converted to 1979 U.S. dollars. The conversion of the 1979 Austrian losses is the easiest. The exchange rate was 13.368 schillings per U.S. dollar in 1979. Converting to exponential notation, the losses were 1.972×10^9 schillings. This converts to a fire loss in U.S. dollars as follows:

$$\text{Fire Loss} = \frac{1.972 \times 10^9}{13.368} = \$1.475 \times 10^8.$$

The 1980 fire losses must be "stepped down" to the 1979 values. The step down is accomplished by the ratio of the consumer price indexes (CPI's) as follows:

$$\text{Step Down} = \frac{CPI_{1979}}{CPI_{1980}} = \frac{172.9}{183.9} = 0.940.$$

The loss in 1980 was 1.137×10^9 schillings. This is stepped down to 1979 schillings as follows:

$$\text{Fire Loss} = .940 \times 1.137 \times 10^9 = 1.069 \times 10^9 \text{ (in 1979 schillings).}$$

This value must now be converted to 1979 U.S. dollars as follows:

$$\text{Fire Loss} = \frac{1.069 \times 10^9}{13.368} = \$.7997 \times 10^8 \text{ (in 1979 U.S. dollars).}$$

The average fire loss is given by:

$$\text{Average Fire Loss} = \frac{(1.475 + .7997) \times 10^8}{2} = \$1.3735 \times 10^8 .$$

B.1.3 Belgium

Data was obtained from the 1979 and 1980 fire service statistics prepared by the Minister of the Interior [3]. These data provided information on the number of building fires, but the monetary fire losses could not be determined.

a) Building Fires. Table 1 of each referenced document contains general statistics by nature of the fire leading to the following compilation:

	1979	1980	Average
Building Fires	14,036	13,874	
Chimney Fires	2,632	3,187	
Total Building Fires	16,668	17,061	16,864

B.1.4 Canada

Data for 1979 was obtained from the "Report of the Dominion Fire Commissioner [11]. Information on both fires and monetary loss was available.

a) Building Fires. The number of building fires was determined by summing the components of Table 3 of the referenced document. These components and their contributions were as follows:

Residential	40,620
Institutional and Assembly	3,512
Farm Properties	1,297
Manufacturing Properties	2,354
Mercantile Properties	2,989
Miscellaneous Properties	32,335
Total	83,107

In the letter of transmittal of the data, G. A. Hope, Dominion Fire Commissioner informed us that "transportation fires" are included in this total. After conversing with Mr. Hope, a call was received from Mr. John Johnson, the statistician responsible for the report. Mr. Johnson determined that 19% of the fires in Ontario Province were "vehicle fires" and that 4% of the losses were associated with vehicles. It was Mr. Johnson's feeling that extrapolation to all of Canada is acceptable, since Ontario contains 35% of the population. Thus, the number of building fires in Canada in 1979 is estimated as 67,317.

b) Fire Loss. Table 3, discussed above, also contains data on losses. The components and their contributions were as follows.

Residential	C$294,067,558
Institutional and Assembly	92,548,876
Farm Properties	26,984,099
Manufacturing Properties	78,453,510
Mercantile Properties	100,354,699
Miscellaneous Properties	164,018,399
Total	C$756,427,141

As discussed above, 4% is subtracted from the above total resulting in a 1979 fire loss estimate of 7.262×10^8 Canadian dollars.

Now, these losses must be converted to 1979 U.S. dollars. The exchange rate was 1.1714 Canadian dollars per U.S. dollar in 1979. Converting to exponential notation, the losses were 7.564×10^8 Canadian dollars. This converts to a fire loss in U.S. dollars as follows:

$$\text{Fire Loss} = \frac{7.564 \times 10^8}{1.1714} = \$6.457 \times 10^8.$$

B.1.5 Denmark. Data were obtained from the Danish Insurance Information Office, including the document "Brandskader" for 1979 [9]. From this publication, the number of fire insurance claims and monetary fire loss was obtained. The data were issued by the Danish Statistical Department and are based on information from insurance companies. Using prior estimates of fire incidents provided by the Danish Fire Inspection Agency, the number of building fires was estimated.

a) Building Fires. From 1975 through 1978, the Danish Fire Inspection Agency estimated the total number of fires at 17,000 when the number of insurance claims were in the neighborhood of 110,000. The proportion of incidents to claims is approximately .155. In 1979, there were 100,204 relevant claims [9]. Applying the proportion leads to the following estimate of the number of building fires:

$$\text{Building Fires Estimate} = .155 \times 100{,}204 = 15{,}532.$$

b) Fire Loss. The 1979 issue of "Brandskader (Fire Loss)" was used to determine monetary losses. In Table 1, the total fire loss (in millions of kroner) is given. To determine building fires, the following equation (terms translated into English) was used:

Building Fire Loss = Total Fire Loss - (Forests + Ships/Vessels + Buiness Interruption) Fire Losses.

For, 1979, the result is as follows:

$$\text{Building Fire Loss} = 1092.5 - 0 - 3.4 - 32.3 = 1056.8.\ (\text{x}10^6 \text{ kroner}).$$

Now, these losses must be converted to 1979 U.S. dollars. The exchange rate was 5.2610 kroner per U.S. dollar in 1979. This converts to a fire loss in U.S. dollars as follows:

$$\text{Fire Loss} = \frac{10.568 \times 10^8}{5.2610} = \$2.009 \times 10^8.$$

B.1.6 France

Data concerning building fires were obtained from documents prepared by the Direction de la Sécurité Civile for the years 1978-1979 and 1980 [14]. Data concerning fire loss was obtained from Assembleé Plénière des Société d'Assurances, and is based on fire claims for 1979 and 1980 [1].

a) Building Fires. Data for the number of building fires were obtained from [14]. On page 39 of the 1978-79 document and page 30 of the 1980 version, a graph appears describing the number of fire interventions (excluding chimney fires) in the sub-categories shown below:

	1979	1980
Residential Fires		
Dwelling Places	34,112 (43,184)	38,650 (48,484)
Non-Residential Fires		
Public Assembly	4,598	4,749
Industry	3,575	3,748
Warehouse, Depts, Docks	1,815	1,832
Total	9,988 (12,644)	10,329 (12,957)
Mobile Fires		
Transportation	15,656 (19,819)	17,893 (22,445)

	1979	1980
Outside Fires		
Brush	21,532	20.472
Forests	5,681	5,040
Agricultural	6,516	6,355
Total	33,729 (42,699)	31,867 (39,975
Other Fires	24,861	25,122
Total Fires	118,346	123,861
Chimney Fires	27,072	35,070
Grand Total Fires	145,418	158,931

The chimney fires were obtained from graphs on pages 38 and 28 of the two documents, respectively.

First, the "Other Fires" are apportioned to the four classes that appear previously. The results are shown in parentheses in the above table.

Next, compute the proportion of building fires which are residential and those which are non-residential:

	1979	1980
Residential	43,184/55,828 = .774	48,484/51,441 = .789
Non-Residential	12,644/55,828 = .226	12,957/61,441 = .211

Now, apportion the chimney fires to residential and non-residential classes as follows:

	1979	1980
Residential	27,072 x .774 = 20,953	35,070 x .789 = 27,670
Non-Residential	27,072 x .226 = 6,119	35,070 x .211 = 7,400

And finally, compute new values for residential and non-residential fires as follows:

	1979	1980
Revised Residential	43,184 + 20,953 = 64,137	48,484 + 27,670 = 76,154
Revised Non-Residential	12,644 + 6,119 = 18,763	12,957 + 7,400 = 20,357

In summary,

	1979	1980	Average
Building Fires	(82,900)	(96,511)	89,705
Residential	64,137	76,154	
Non-Residential	18,763	20,357	
Mobile	19,819	22,445	
Outside	42,699	39,975	
Total	145,418	158,931	

b) Fire Loss. Losses for 1979 and 1980 are classified as Domestic, Industrial, and Agricultural in [14]. The Agricultural losses were estimated as 50% Building Fires and 50% Outside Fires. Thus, 50% of Agricultural Fires are to be redistributed. The fire loss must be augmented for:

i) Losses not insured (add 3%)

ii) Losses underinsured (add 7 1/2%).

These percentage additions are in accordance with the work of Wilmot [38]. Thus, the following total losses ($x\ 10^6$ francs) result:

	Losses ($x\ 10^6$ francs)	
	1979	1980
Domestic	3,190	3,642
Industrial	2,565	3,071
Agricultural	1,032	945
Total Fire Claim Losses	6,787	7,658
Modified Total	7,499.64	8,462.09

Now, the building fire loss is estimated using the following equation which distributes the agricultural losses as discussed previously:

$$\text{Building Fire Loss} = \frac{\text{Original Total} - 1/2\ (\text{Original Agricultural})}{\text{Original Total}} \times \text{Modified Total.}$$

For 1979, the result is as follows:

$$\text{Building Fire Loss } (x\ 10^6 \text{ francs}) = \frac{6,787 - 1/2\ (1,032)}{6,787} \times 7.499.64 = 6,929.46.$$

For 1980, the result is as follows:

$$\text{Building Fire Loss } (x\ 10^6 \text{ francs}) = \frac{7,658 - 1/2\ (945)}{7,658} \times 8,462.09 = 7,939.98.$$

Now, these losses must be converted to 1979 U.S. dollars. The exchange rate was 4.2545 francs per U.S. dollar in 1979. Converting to exponential notation, the losses were 6.92946×10^9 francs. This converts to a fire loss in 1979 U.S. dollars as follows:

$$\text{Fire Loss} = \frac{6.92946 \times 10^9}{4.2545} = \$1.629 \times 10^9 .$$

The 1980 fire losses must be "stepped down" to the 1979 values. The step down is accomplished by the ratio of the consumer price indexes (CPI's) as follows:

$$\text{Step Down} = \frac{CPI_{1979}}{CPI_{1980}} = \frac{221.3}{251.3} = 0.881 .$$

The loss in 1980 was $7{,}939.98 \times 10^6$ francs. This is stepped down to 1979 francs as follows:

$$\text{Fire Loss} = .881 \times 7{,}939.98 \times 10^6 = 6.995 \times 10^9 \text{ (in 1979 francs)}.$$

This value must now be converted to 1979 U.S. dollars as follows:

$$\text{Fire Loss} = \frac{6.995 \times 10^9}{4.2545} = \$1.644 \times 10^9 .$$

The average building fire loss is given by

$$\text{Average Building Fire Loss} = \frac{(1.629 + 1.644) \times 10^9}{2} = \$1.6365 \times 10^9 .$$

B.1.7 Germany (F.R.)

Data concerning fire losses were obtained from Bundesaufsichtamtes für vas Veisicherungswesen, Berlin [8]. Specifically, the data for 1979 and 1980 were found in Table 4 on page 170 of the document. The data on fire losses are based on insurance claims.

b) Fire Losses. Table 4 referenced above, contains values of insurance claims for fire losses for 1979 and 1980. These values contain building and non-building fire losses. The precedent has been set in this research to apply 87½% of the fire claims as building fire losses. This results in the following estimates:

$$\text{Building Fire Loss}_{1979} = 2{,}808{,}144{,}000 \times .875 = 2.457 \times 10^9 \text{ dm}$$

$$\text{Building Fire Loss}_{1980} = 2{,}885{,}640{,}000 \times .875 = 2.525 \times 10^9 \text{ dm}.$$

Now, these losses must be converted to 1979 U.S. dollars. The exchange rate in 1979 was 1.8239 dm per U.S. dollar. This converts to a fire loss in U.S. dollars as follows:

$$\text{Building Fire Loss}_{1979} = \frac{2.457 \times 10^9}{1.8239} = \$1.347 \times 10^9.$$

The 1980 fire losses must be "stepped down" to the 1979 values. The step-down is accomplished by the ratio of the consumer price indexes (CPI's) as follows:

$$\text{Step Down} = \frac{CPI_{1979}}{CPI_{1980}} = \frac{155.8}{164.3} = .948.$$

The loss in 1980 was 2.525×10^9 dm. This is stepped down to 1979 dm as follows:

$$\text{Building Fire Loss}_{1980} = .948 \times 2.525 \times 10^9 = 2.394 \times 10^9 \text{ (in 1979 dm)}.$$

This value must now be converted to 1979 U.S. dollars as follows:

$$\text{Building Fire Loss}_{1980} = \frac{2.394 \times 10^9}{1.8239} = \$1.313 \times 10^9 \text{ (in 1979 U.S. dollars)}.$$

The average building fire loss is given by

$$\text{Average Building Fire Loss} = \frac{(1.347 + 1.313) \times 10^9}{2} = \$1.33 \times 10^9.$$

B.1.8 Ireland

Data concerning fire incidents and losses were obtained from a compilation of fire bigade statistics for 1979. The statistics are based on local authority returns submitted to the Department of the Environment, Fire Services Section [17]. In the letter of transmittal, the Chief Fire Officer stated that "the fire reporting system here (In Ireland) is quite primitive and does not, in my opinion, reflect the situation as it exists in the country."

a) Building Fires. Beginning on page 4 is a table entitled, "Classification and Location of Fires." The columns were assigned to Residential, Non-Residential, Mobile and and Outside with the following results:

Residential Fires	
Private House	18,124
Caravans/Mobile Homes	195
Hotels	153
Flats	571
Total	19,043
Non-Residential Fires	
Institutions	336
Industrial	783
Commercial	306
Places of Public Entertainment	49
Public Houses	114
Restaurants and Clubs	36
Petrol Stations and Garages	155
Agricultural Premises	679
Total	2,458
Mobile Fires	
Hazardous Substances in Transit	14
Motor Vehicles	2,398
Ships	11
Total	2,423

Outside Fires	
Forest	139
Bog, Grass, etc.	2,192
Total	2,331
Miscellaneous Fires	3,451
Grand Total Fires	29,706

The miscellaneous fires are now apportioned to the four previous categories to obtain the results below:

Building Fires	(24,327)
Residential	21,546
Non-Residential	2,781
Mobile	2,742
Outside	2,637
Total	29,706

b) <u>Fire Losses</u>. The table on the last page of the document mentioned previously contains a column headed "Estimated Material Fire Loss," in the amount of 24,727,788 Irish pounds. Since these fire losses included mobile and outside losses, a factor of 5% was subtracted for each of these. This gives an approximate building fire loss of 23,155,009 Irish pounds.

Now, these losses are converted to U.S. dollars. The exchange rate in 1979 was 2.0476 dollars per pound. First, the fire loss is converted to exponential form as 2.316×10^7 Irish pounds. The fire loss for 1979 is calculated in U.S. dollars as follows:

$$\text{Fire Loss} = 2.316 \times 10^7 \times 2.0476 = \$4.742 \times 10^7.$$

B.1.9 Japan

Extensive data on fire damages in Japan are reported in the White Book [18]. The Fire Defense Agency of Japan prepares the White Book every two years. Data for this report were taken from the 1980 White Book with information about fires that occurred in 1979.

a) Building Fires. Exhibit 31 contains information on losses from building fires by type of structure. The total number of building fires for 1979 was 38,291.

b) Fire Loss. Exhibit 31 also contains the amount of fire loss for each type of building structure. The total monetary loss from building fires in 1979 is indicated as 131,131 million yen.

Now, these losses must be converted to 1979 U.S. dollars. The exchange rate was 219.14 yen per U.S. dollar in 1979. Converting to exponential notation, the losses were 1.311×10^{11} yen. This converts to a fire loss in U.S. dollars as follows:

$$\text{Fire Loss} = \frac{1.311 \times 10^{11}}{2.1914 \times 10^{2}} = \$5.982 \times 10^{8}.$$

B.1.10 Netherlands

Data for 1979 come from the document "Statistiek der Branden" [12]. This document provides detailed information about fires by occupancy type, by cause of fire, and by heat source. Also provided by the Netherlands Centraal Bureau of Statistics were the provisional data for 1980 [12], which is not in the level of detail of the first mentioned data source. However, from each of those documents, the number of building fires and associated monetary loss can be determined.

a) Building Fires. The number of building fires was determined from Table 7 of the first referenced source and Table 5 in the second referenced source. In the source table the designation "Gebouwen" (Buildings) is given. All losses in this category are included in the building fire (and monetary loss) categories. In addition "woongegenheden" (shipboard living and mobile homes) from "Geen Gebouwen" (not buildings) was included. This method of analysis results in 12,482 building fires in 1979 and 12,466 building fires in 1980. The average number of building fires is 12,474.

b) Fire Loss. From Table 12 of the 1979 data source, the monetary fire loss is determined (in the manner described above) to be $589{,}813 \times 10^3$ guilders. Using Table 5 of the second referenced source, the monetary fire loss for 1979 is determined (in the manner described above) to be $633{,}072 \times 10^3$ guilders.

Now, these losses must be converted to 1979 U.S. dollars. The exchange rate was 2.0060 guilders per U.S. dollar in 1979. This converts to a fire loss in U.S. dollars as follows:

$$\text{Fire Loss} = \frac{6.331 \times 10^8}{2.0060} = \$3.156 \times 10^8.$$

B.1.11 New Zealand. Building fire data for 1979 and 1980 come from the "Report of the New Zealand Fire Service Commission" [23]. This data is based on reports from several hundred fire brigades which are amalgamated into a national fire service commission. No information concerning fire loss is currently available.

a) Building Fires. Table I is an Analysis of Calls and Table II an Analysis of Property Involved. From these two tables, the following is constructed :

	1979	1980
Residential Fires		
Dwellings and Accomodation Buildings	5,202	4,823
Non-Residential Fires		
Places of Public Assembly	216	199
Shops and Offices	430	372
Manufacturing and Industrial	771	729
Bulk Stores and Warehouses	40	25
Total	1,457	1,323
Mobile Fires		
Transport Road, Rail, Marine and Air	2,648	2,612
Outside Fires		
Gorse, Grass, Rubbish	7,408	6,246
Other Fires		
Agricultural Buildings and Property	252	223
Miscellaneous Buildings	262	250
Miscellaneous Property	205	198
Chimney Fires	3,475	3,191
	4,194	3,862
Total All Fires	20,909	18,866

There are four categories of "Other Fires." The "Miscellaneous Buildings" and "Chimney Fires" are distributed proportionately to Residential and Non-Residential categories. The "Agricultural Buildings and Property" and "Miscellaneous Property" are distributed equally to Non-Residential and Outside categories. The distribution results in the following:

	1979	1980	Average
Building Fires	(10,625)	(9,798)	10,211
Residential Fires	8,121	7,524	
Non-Residential Fires	2,504	2,274	
Mobile Fires	2,648	2,612	
Outside Fires	7,636	6,456	
Total Fires	20,909	18,866	

B.1.12 Norway

Data for Norway were obtained from "Branner i Norge (Proof)" for 1979 [24] and provisional data transmitted for 1980 [24]. The data are based on reports from all fire insurance companies underwriting in Norway. Sufficient data are available for the determination of building fires and monetary fire losses.

a) Building Fires. The number of building fires for 1979 is obtained using Table 1 under the column heading Tilsammen, (Total) and further sub-headings Antall Branner (All Fires). The number in Table 1 for 1979 is 17,832. The provisional number of fires for 1980 is 20,000. Further analysis of "Branner i Norge" has indicated that some of the fires included in Table 1 are non-building fires. Nearly 2% of these could be readily identified. However, it has been estimated that this percentage is low and should be raised to 5%. Thus, 95% of the fires in 1979 and 1980 result in building fire estimates of 16,940 and 19,000, respectively. The average for the two years is 17,970.

b) Fire Loss. The 1979 fire loss can be obtained using Table 1, under the column (Tilsammen - Erstatning) as 899,016,725 kroner. This sum includes "consequential" (indirect losses of about 6.5% determined from correpsondence with A. Rydning of Norges Brannkasse [29]. Thus, direct fire loss for 1979 is about 8.406×10^8 kroner. The provisional estimate for 1980 is about 8.970×10^8 kroner after subtracting indirect losses. These data are then multiplied by 95%, since that is the proportion of fires which are estimated to be in buildings. The results are as follows:

$$\text{Loss for 1979} = .95 \times 8.406 \times 10^8 = 7.986 \times 10^8 \text{ kroner}$$

$$\text{Loss for 1980} = .95 \times 8.970 \times 10^8 = 8.521 \times 10^8 \text{ kroner.}$$

Now, these losses must be converted to 1979 U.S. dollars. The conversion of the 1979 Norwegian loss is the easiest. The exchange rate was 5.0641 kroner per U.S. dollar in 1979. This converts to a fire loss in U.S. dollars as follows:

$$\text{Fire Loss} = \frac{7.986 \times 10^8}{5.0641} = \$1.577 \times 10^8 .$$

The 1980 fire losses must be "stepped down" to the 1979 values. The step down is accomplished by the ratio of the consumer price indexes (CPI's) as follows:

$$\text{Step Down} = \frac{CPI_{1979}}{CPI_{1980}} = \frac{201.7}{223.6} = 0.902.$$

The loss in 1980 was 8.521×10^8 kroner. This is stepped down to 1979 kroner as follows:

$$\text{Fire Loss} = .902 \times 8.521 \times 10^8 = 7.686 \times 10^8 \text{ (in 1979 kroner)}.$$

This value must now be converted to 1979 U.S. dollars as follows:

$$\text{Fire Loss} = \frac{7.686 \times 10^8}{5.0641} = \$1.518 \times 10^8 \text{ (in 1979 U.S. dollars)}.$$

The average fire loss is given by

$$\text{Average Fire Loss} = \frac{(1.577 + 1.518) \times 10^8}{2} = \$1.5475 \times 10^8 .$$

B.1.13 Switzerland

Data for Switzerland were obtained from "Brandstatistik 1979 (Fire Statistics for 1979)" [31]. This document is based on reports from all fire insurance companies underwriting in Switzerland. Sufficient data are available for the determination of building fires and monetary fire losses.

a) Building Fires. The number of building fires is obtained from Table B, under the column heading "Zahlder betroffenen Gebäude" (Buildings in Which Loss Occurred), and "davon direkt" (Fire as a Direct Cause). The number of building fires in 1979 is given by 11,488.

b) Fire Loss. In Table B, the monetary loss of the buildings lost to fire in 1979 is given as 122,632,894 Swiss francs. This is found in the column headed "Schadensumme der betroffenen Gebaude" and subheaded "davon direkt." Translated, the two titles combined would read "Total Direct Losses in Buildings."

Now, this loss must be converted to 1979 U.S. dollars. The exchange rate in 1979 was 1.6627 francs per U.S. dollar. Converting to exponential notation, the losses were 1.226×10^8 francs. This converts to a fire loss in U.S. dollars as follows:

$$\text{Fire Loss} = \frac{1.226 \times 10^8}{1.6227} = \$7.555 \times 10^7.$$

B.1.14 United Kingdom

Data on building fires for 1979 was obtained from "United Kingdom Fire Statistics," prepared by the Home Office [6]. Data concerning losses were obtained from "Insurance Facts and Figures," prepared by the British Insurance Association [7].

a) Building Fires. In numerous places in the "Statistics," the fires in occupied buildings are given as 99,979. To this number are added the following building fires from Table 44:

Derelict Buildings	15,144
Electrical Supply Plant	674
Gas Works Plant and Mains	199
Caravans	1,242
Total	17,259

The total building fires are equal to 117,238.

b) Fire Losses. The major source of data concerning fire losses is a pamphlet published annually by the British Insurance Association [7]. The 1980 edition of "Insurance Facts and Figures" contains data about 1979 and 1980. On page 10, there is a set of bar graphs of estimated annual fire damage. For 1979, 355.3×10^6 pounds sterling of damage is estimated for Great Britain (England, Scotland and Wales). (For 1980, the value was 469.3×10^6 pounds sterling.) In prior editions of the pamphlet, estimates for Northern Ireland were given separately. However, the Associations "discontinued publishing an estimate for fire damage in Northern Ireland because of the statistical uncertainties that increasingly surrounded (the) figures for that area." [15] From 1970 through 1977, the relationship between the losses in Northern Ireland and Great Britain was between .040 and .301 of the total, with a median value of about .10. Using this estimate for Northern Ireland results in the following:

$$\text{Fire Loss}_{1979} = 355.3 \times 10^6 \times 1.1 = 390.83 \times 10^6 \text{ pounds sterling}$$

$$\text{Fire Loss}_{1980} = 469.3 \times 10^6 \times 1.1 = 516.23 \times 10^6 \text{ pounds sterling.}$$

From these totals, a value of 7 1/2 percent is subtracted, since it is known that some outside fire losses are included. From Wilmot's prior study [38], it is known that mobile fire loss is not in the total so no adjustments are required to remove this class of fires. The estimated building fire losses can then be determined as follows:

$$\text{Building Fire Loss}_{1979} = 390.83 \times 10^6 \times .925 = 361.52 \times 10^6 \text{ pounds sterling}$$

$$\text{Building Fire Loss}_{1980} = 516.23 \times 10^6 \times .925 = 477.52 \times 10^6 \text{ pounds sterling.}$$

Now, these losses must be converted to 1979 U.S. dollars. The exchange rate was 2.1216 U.S. dollars per pound sterling in 1979. This converts to a fire loss in U.S. dollars as follows:

$$\text{Building Fire Loss}_{1979} = 361.52 \times 10^6 \times 2.1216 = \$7.6700 \times 10^8.$$

The 1980 fire losses must be "stepped down" to the 1979 values. The step down is accomplished by the ratio of the consumer price index (CPI's) as follows:

$$\text{Step Down} = \frac{CPI_{1979}}{CPI_{1980}} = \frac{305.8}{360.8} = 0.848.$$

The loss in 1980 was 477.52×10^6 pounds sterling. This is stepped down to 1979 pounds sterling as follows:

$$\text{Building Fire Loss}_{1979} = 477.52 \times 10^6 \times .848 = 4.0494 \times 10^8 \text{ (in 1979 pounds sterling).}$$

The value must now be converted to 1979 U.S. Dollars as follows:

$$\text{Building Fire Loss}_{1980} = 4.0494 \times 10^8 \times 2.1216 = \$8.5912 \times 10^8 .$$

The average fire loss is given by

$$\text{Average Fire Loss} = \frac{(7.6700 + 8.5912) \times 10^8}{2} = \$8.1306 \times 10^8 .$$

B.1.15 United States.

Information concerning building fires and monetary fire losses for 1979 and 1980 were provided by the USFA [21]. These values are preliminary National

Estimates which, when finalized, usually become a portion of the document "Fire in the United States."

a) Building Fires. Three categories from the National Estimates are summed to obtain the number of building fires as follows:

	1979	1980	Average
Residential	702,593	725,622	
Public/Mercantile	146,928	125,697	
Industry	159,811	131,879	
Total Building Fires	1,009,332	983,198	996,265

b) Fire Losses. The categories of property loss from the National Estimates are summed to obtain fire losses (in $1,000's) as follows:

	1979	1980
Residential	2,339,262	2,809,580
Public/Mercantile	820,385	1,154,235
Industry	1,338,524	1,187,013
Total Fire Losses ($1,000's)	$4,498,171	$5,150,828

The 1979 estimate is converted to exponential form as $\$4.4982 \times 10^9$. The 1980 losses must be "stepped down" to 1979 values. The step down is accomplished by the ratio of the consumer price indexes (CPI's) as follows:

$$\text{Step Down} = \frac{CPI_{1979}}{CPI_{1980}} = \frac{187.2}{212.4} = .881.$$

The loss in 1980 was $\$5.1508 \times 10^9$. This is stepped down to 1979 as follows:

$$\text{Fire Loss} = .881 \times \$5.1508 \times 10^9 = \$4.5379 \times 10^9.$$

Thus, the average fire loss in 1977 dollars was as follows:

$$\text{Average Fire Loss} = \frac{(\$4.4982 + \$4.5379) \times 10^9}{2} = \$4.5180 \times 10^9.$$

B.2 Procedure for Computation of Percentage Changes in Table 2-2

In all cases appearing in this appendix, the United States computations are used as an example.

Building Fires/1,000 Persons

$$\% \text{ Change} = \frac{(\text{No. of building fires/1,000 persons for 1979-80}) - (\text{No. of building fires/1,000 persons for 1976-78})}{(\text{No. of building fires/1,000 persons for 1979-80})} \times 100$$

$$= \frac{4.6 - 4.8}{4.6} \times 100 = -4.3.$$

\$ Building Fire Loss Per Capita

Monetary values are compared on a 1977 basis. Therefore, values for the 1979-80 time period must be stepped down to 1977 dollars as follows:

$$\text{Step down} = \frac{CPI_{1977}}{CPI_{1979}} = \frac{167.3}{187.2} = .894$$

The per capita loss in 1979-80 was \$20.9 and is stepped down to 1977 dollars as follows:

Fire loss = (.894)(20.9) = 18.7 (in 1977 dollars).

Percentage change is calculated as follows:

$$\% \text{ Change} = \frac{(\text{\$Building fire loss per capita for 1979-80}) - (\text{\$ Building fire loss per capita for 1979-80})}{(\text{\$ Building fire loss per capita for 1979-80})} \times 100$$

$$= \frac{18.7 - 19.6}{18.7} \times 100 = -4.8.$$

Building Fire Loss as Percent of GNP

Percentage change is calculated as follows

$$\% \text{ Change} = \frac{\text{Building fire loss for 1979-80)} - \text{(Building fire loss for 1976-78)}}{\text{(Building fire loss for 1979-80)}} \times 100$$

$$= \frac{.195 - .23}{.195} \times 100 = -17.9.$$

Fire Deaths/1,000,000 Persons

Percentage change is calculated as follows:

$$\% \text{ Change} = \frac{\text{(Fire deaths for 1979-80)} - \text{(Fire deaths for 1976-78)}}{\text{(Fire deaths for 1979-80)}} \times 100$$

$$= \frac{29 - 34}{34} \times 100 = -17.2.$$

Building Fire Losses/Fire ($1,000's)

Again, the 1979-80 value for fire loss must be stepped down to 1977 dollars for comparison. The step down factor was calculated previously to be .894. The fire loss per fire is stepped down as follows:

Fire loss/fire = (.894)(4.5) = 4.0 (in 1,000's of 1977 dollars).

The percentage change is calculated as follows:

$$\% \text{ Change} = \frac{\text{(Fire deaths/1,000 building fires for 1979-80)} - \text{(Fire deaths/1,000 building fires for 1976-78)}}{\text{(Fire deaths/1,000 building fires for 1979-80)}} \times 100$$

$$= \frac{6.4 - 7.2}{6.4} \times 100 = -12.5.$$

Mobile	
Aircraft	4
Motor Vehicles	43
Tank Trucks	1
Total	48
Outside	
Forest and Bush	7
Out of Door	2
Total	9

In summary, the fire deaths by occupancy are as follows:

Building Fire Deaths	
Residential	617
Non-Residential	59
Mobile Fire Deaths	48
Outside Fire Deaths	9
Total	733

B.3.2. Japan

Japanese figures for 1979 in Table 3-1 were derived primarily from Exhibits 1, 12 and 31 of the White Book on Fire Service in Japan [18]. From Table 3-1, the number of fires by occupancy is determined as follows:

Building Fires	38,291
Mobile Fires	
Vehicle	3,639
Vessel	244
Aircraft	4
Outside Fires	
Forest	5,534
Other	16,082
Total	63,794

The number of building fires is subdivided further using Exhibit 3-1 as follows:

Residential	
Dwelling Houses	18,959
Hotels and Inns	391
Total Residential	19,350
All Other Building Fires (Non-Residential)	18,941
Total Building Fires	38,291

In summary, the numbers of fires by type of occupancy is as follows:

Residential Fires	19,350
Non-Residential Fires	18,941
Mobile Fires	3,887
Outside Fires	21,616
Total Fires	63,794

From Exhibit 12, and the surrounding narrative, the casualties by type of fire can be determined as follows:

Building Fires	
Residential	1,291
Non-Residential	159
Mobile Fires	
Vehicles	124
Vessel	7
Airplane	0
Outside Fires	
Forest	38
Other	451
Total	2,070

These death data are summarized as follows:

Residential	1,291
Non-Residential	159
Mobile	131
Outside	489
Total	2,070

The fire death data are then scaled to match the World Health Organization information.

The losses from fires are obtained from combining information from Exhibit 1 and 31 to yield (in millions of yen) the following:

Building Fires Losses	131,131
Residential Losses	
Dwelling Houses	41,868
Hotels and Inns	2,020
Total Residential	43,888
Non-Residential Losses (By Subtraction)	87,243
Mobile Fire Losses	
Vehicles	1,780
Vessels	610
Airplanes	5
Total Mobile Fire Losses	2,395
Outside Fire Losses	
Forest	1,472
Others	1,829
Total Outside Fire Losses	3,301
Total Losses	136,827

These losses (in millions of yen) are summarized as follows:

Residential	43,888
Non-Residential	87,243
Mobile	2,395
Outside	3,301
Total	136,827

The losses are then converted by using an exchange rate of 219.4 yen per U.S. dollar. Thus, $43,888 \times 10^6$ yen becomes $\$200.4 \times 10^6$. Then, the losses (denominated in $\$10^6$) are as follows:

Residential	$200.3
Non-Residential	398.1
Mobile	10.9
Outside	15.1
Total	$624.4

B.3.3 Netherlands

Table 3-1 fire incident information for the Netherlands was derived from totals of the more detailed Tables 3-2 through 3-5. The latter were, in turn, calculated as described in Section B.5.1 below.

Monetary loss information in Table 3-1 was computed from Staat 12 of the Dutch reports [12] for 1979. The classification is approximately that of Table B-2 except that the unexplained "Overage", in each instance, was apportioned to the categories preceding it. The results for Building Fires are as follows, prior to the allocation of the unexplained, with losses in guilders $\times 10^3$:

Building Fire Losses (Excluding Caravans, etc.)

Residential	87,660
Non-Residential	471,135
Unexplained	27,383
Total	586,178

After distributing the unexplained in proportion to the representation of each category, the Building Fire Losses are as follows:

Building Fire Losses (Excluding Caravans, etc.)

Residential	91.956
Non-Residential	494,222
Total	586,178

The Non-Building Fire Losses are as follows:

Non-Building Fire Losses	
Caravans, etc	3,635 (Residential)
Open Air Markets, Circuses, etc.	1,611 (Non-Residential)
Mobile	18,883
Outside	3,664
Unexplained	2,410
Total	30,203

It will be noted that the Non-Building Fire Losses include two categories which are generally classified in this research as Building Fire Losses. First, distributing the unexplained portion proportionately yields the following result:

Non-Building Fire Losses	
Caravans, etc.	3,950 (Residential)
Open Air Markets, Circuses, etc.	1.751 (Non-Residential)
Mobile	20,520
Outside	3,982
Total	30,203

Next, placing the two categories of Non-Building Fire Losses into their appropriate categories results in the following summary:

Building Fire Losses	($x\ 10^3$ guilders)
Residential	95,906
Non-Residential	495,973
Mobile Fire Losses	20,520
Outside Fire Losses	3,982
Total	616,381

These values must now be converted to U.S. dollars. The exchange rate in 1979 was 2.0060 guilders per U.S. dollar. Thus, the 1979 Netherlands fire losses are as follows:

Building Fire Losses	($\times 10^6$)
Residential	$ 47.810
Non-Residential	247.244
Mobile Fire Losses	10.229
Outside Fire Losses	1.985
Total	$307.268

B.3.4 New South Wales

Table 3-1 fire incident information for Australia's State of New South Wales was obtained from totals in Tables 3-2 through 3-5. The latter tables, in turn were prepared as outlined in Section B.5.2. below.

The fire death information is obtained from Table 48, for residential and non-residential occupancies only, in the following manner:

Residential Fatalities	
Dwelling Houses	20
Flats, etc.	7
Group Accommodations	1
Total	28
Non-Residential (By Subraction)	3
Total	31

It was not possible to determine Mobile and Outside casualties separately. The fire death data are then scaled to match the World Health Organization information.

The losses can be approximated, but only for residential fires. Table 29 contains information on the estimated losses by occupancy in ranges.

Using the midpoint of each range as the loss for every fire occuring in the range results in a 1979 estimate of AUS \$15,134,250. The conversion rate was 1.1179 U.S. dollars per Australian dollar in 1979. Thus, the residential losses are estimated as \$$1.692 \times 10^7$. The non-residential fire losses could not be estimated since the overflow category had four entries.

B.3.5 United Kingdom

As with the Netherlands and New South Wales, United Kingdom information in Table 3-1 follows from more detailed computations of Tables 3-2 through 3-5. Fire incident information appearing in Table 3-1 was taken directly from subtotals of the latter tables.

Fire death data was derived from Tables 23 and 44 of the United Kingdom report [6] with the following regrouping:

Residential Casualties	
Dwellings	865
Hotels	0
Hostels, etc.	5
Caravans	14
Total	884
Non-Residential Casualties	
Total Building Fire Casualties	954
(Less) Residential Casualties	(884)
Caravans	14
Total	84

Mobile	
Road Vehicles	68
Ships and Boats	1
Total	69
Outside	
Outdoor Machinery and Equipment	6
Other Outside	48
Total	54

In summary, the casualties during 1979 in the United Kingdom are as follows:

Residential	884
Non-Residential	84
Mobile	69
Outside	54
Total	1,091

The fire death data is now scaled to match the World Health Organization fatality rates.

B.3.6 United States

All United States values in Table 3-1 were derived directly from summaries in the 1979 and 1980 estimates [21]. The numbers of fires by occupancy also appeared in Tables 3-2 through 3-5, but are repeated herein for 1979, as follows:

	Fires	Deaths	Loss (x10^6)
Residential	702,593	6,206	$2,339.3
Non-Residential	306,739	680	2,158.9
Mobile	490,688	744	613.5
Outside	1,233,955	170	439.8
Total	2,733,975	7,800	$5,551.5

Similarly, the data for 1980 are as follows:

	Fires	Deaths	Losses (x10^6)
Residential	725,622	6,039	$2,809.6
Non-Residential	257,576	423	2,341.2
Mobile	460,047	802	638.0
Outside	1,451,272	336	135.0
Total	2,897,517	7,600	$5,923.8

B.4 Derivations of Values in Tables 3-2 through 3-5

Tables 3-2 through 3-5 provide detailed breakdowns of numbers of fires by occupancy and cause. U.S. results were taken directly from the draft report Fire in the United States 1979-80 [21]. The only changes were in combining those fires classified as "Public Assembly" and "Eating, Drinking" in the U.S. report into "Public Assembly" occupancy.

Values for the Netherlands, the United Kingdom and Australia's New South Wales were obtained by reallocating information provided in comparable reports. The next three subsections detail the approach taken. Table B-1 defines the classification codes referenced in those subsections.

Among those codes, C12 represents fires of unknown cause. In Tables 3-2 and 3-3 all fires classified C12 were distributed in proportion to incidents of known cause.

B.4.1 Netherlands

Netherlands' results in [12] do not directly present occupancy versus cause tables. Instead, Tables 20A and 20B array heat source of ignition versus occupancy, Table 22 shows ignition factor versus occupancy, and Table 24 shows heat source versus ignition factors for building fires only. Table 24 shows that heat source-oriented cause categories in the U.S. system (C1, C3, C5, C6, etc.) have almost no overlap with ignition factor-oriented ones (C2, C4, C7, etc.), i.e., incidents in these categories of Tables 20A/20B and of Table 22 are generally unduplicated.

On the basis of this analysis, Netherlands' data in Tables 3-2 through 3-5 were obtained by selecting heat source-oriented cause information (by occupancy) from Tables 20A and 20B, draining ignition factor-oriented cause information (by occupancy) from Table 22, and dividing any residual in each occupancy category evenly among C8 and C15. Table B-2 shows details of the reclassifications.

TABLE B-1. CLASSIFICATION CODES

<u>Residential Property:</u>

R1 = One and Two Family Dwellings

R2 = Apartments, Tenements, and Flats

R3 = Mobile Homes

R4 = Hotels, Motels, Inns, and Lodges

R5 = Other Residential

R* = Total Residential

<u>Non-Residential Structures:</u>

N1 = Public Assembly

N2 = Education

N3 = Institutions

N4 = Stores and Offices

N5 = Basic Industry

N6 = Manufacturing

N7 = Storage

N8 = Vacant, Construction

N9 = Other

N* = Total Non-Residential Structure

<u>Mobile Property:</u>

M1 = Automobiles

M2 = Other Motor Vehicles

M3 = Rail, Water, and Air Transportation

M4 = Other Mobile

M* = Total Mobile

<u>Outside Property:</u>

O1 = Refuse

O2 = Trees, Grass and Brush

O3 = Forests

O4 = Crops

O5 = Other Outside

O* = Total Outside

<u>Causes:</u>

C1 = Cooking

C2 = Smoking

C3 = Heating

C4 = Incendiary/Suspicious

C5 = Electrical Distribution

C6 = Appliances

C7 = Children Playing

C8 = Open Flame, Spark

C9 = Exposure

C10 = Natural

C11 = Other

C12 = Unknown

TABLE B-2. NETHERLANDS CLASSIFICATIONS

(a) Occupancy

	TOTAAL
GEBOUWEN	Remainder N9 1/
w.v. Woonhuizen	R*
w.v. bewoond	
onbewoond	
Land-, tuin-, bosbouw en visserij	N5
w.v. landbouw en veeteelt	
tuinbouw	
Nijverheid (excl. bouwnijverheid)	N6
w.v. voedings- en genotmiddelen	
textiel en textielwaren, leer, bont e.d.	
hout en meubelen	
papier enz.	
chemische	
bouwmaterialen e.d.	
metaal	
elektro-technische	
transportmiddelen	
Bouwnijverheid en aanverwante bedrijven	N8
Handel, bank- en verzekeringswezen	N4
w.v. winkels, warenhuizen e.d.	
Vervoer- en communicatiebedrijven	Remainder N9
w.v. veem, pakhuizen, opslaggebouwen	N7
Dienstverlening	
w.v. scholen, kerken e.d.	N2
zieken- en bejaardenhuizen, gestichten, kazernes e.d.	N3
gebouwen voor cultuur en ontspanning	N1
horecabedrijven	N1
Kantoren e.d. (z.n.a.)	N4
GEEN GEBOUWEN	Remainder 05
w.v. Woonwagens, -schepen, caravans e.d.	R*
Land-, tuin-, bosbouw	
w.v. landbouwprodukten, bossen e.d.	
w.v. staande gewassen	04
gestapelde gewassen	04
tuinen, plantsoenen	05
staande bomen	03
heide-, duin- en veenterreinen	02
Wegen, straten en terreinen	05
Transportmiddelen	
w.v. straatmotorvoertuigen	M1
Nederlandse schepen	M3
rollend spoorwegmateriaal	M3
spoorweginstallaties	05
Openluchtopslagplaatsen	
w.v. hout	05
afval (vuilnisbelt, slakken)	01
Openluchtinstallaties	Remainder N9
w.v. landbouwmachines e.d.	M4
Openluchtvoorwerpen	2/
w.v. kraampjes, stalletjes langs de weg	
openluchtmarkt, kermis, circus e.d.	

(b) Heat Source (Building Fires)

	TOTAAL
Elektrische toestellen	Remainder C11
w.v. kooktoestellen	C1
ruimteverwarming	C3
verlichting	C5
motor e.d.	C6
waterverwarmer	C3
warmtestraler	C3
radio, t.v., platenspeler	C6
deken, kussen e.d.	C6
droogapparatuur	C6
draden, leidingen, schakelaars	C5
las-, snij- en soldeerapparaat	C8
Gastoestellen	Remainder C11
w.v. kooktoestellen	C1
centrale verwarming	C3
andere ruimteverwarming	C3
waterverwarmer	C3
Vaste brandstoftoestellen	Remainder C11
w.v. centrale verwarming	C3
andere ruimteverwarming	C3
Vloeibare brandstoftoestellen	Remainder C8
w.v. kooktoestellen	C1
centrale verwarming	C3
andere ruimteverwarming	C3
motor	
las-, snij- en soldeerapparaat	
verfafbrander	
Niet gespecificeerde brandstof	C11
Diversen	
w.v. lucifer	
aansteker	
kaars, waxinelicht	
open vuur (z.n.a.)	
brandende stofdelen:	
vuurwerk, explosieven	C11
gloeiende tabak	
vliegvuur	
gloeiend metaal	
brandend, gloeiend afval	
gloeiende brandstofdelen	
mechanische hitte, vonken	
natuurgebeuren:	
bliksem	
andere ontlading v. stat.elektr.	
zelfontbranding, broeiing	
zonnestralen	
Onbekend	

1/ "w.v." in these tables means approximately "subtotals as follows". When all subtotals are not provided, the unallocated remainder of each total was also classified.

2/ Divided 50% N1 and 50% N4.

TABLE B-2. NETHERLANDS CLASSIFICATIONS (CONTINUED)

(c) Heat Source
(Non-Building Fire)

TOTAAL	
Elektrische toestellen	Remainder C11
w.v. verlichting	C5
draden, leidingen, schakelaars	C5
Gastoestellen	Remainder C11
w.v. kooktoestellen	C1
Vaste brandstoftoestellen	Remainder C11
w.v. ruimteverwarming	C3
Vloeibare brandstoftoestellen	Remainder C8
w.v. kooktoestellen	C1
ruimteverwarming	C3
motor	
las-, snij- en soldeerapparaat	
Niet gespecificeerde brandstof	Remainder C11
Diversen	
w.v. lucifer, aansteker	
kaars, waxinelicht	
open vuur e.d.	
brandende stofdelen:	
vuurwerk, explosieven e.d.	C11
gloeiende tabak	
vliegvuur	
brandend, gloeiend afval	
mechanische hitte, vonken	
natuurgebeuren:	
zelfontbranding, broeiing	
zonnestralen	
Onbekend	

(d) Ignition Factor

Totaal		
Brandstichting		C4
Spelen met vuur, baldadigheid		C7
Onvoorzichtigheid bij roken		C2
Vliegvuur		C9
Blikseminslag	Natuurgebeure	C10
Zelfontbranding, broeiing	Natuurgebeure	C10
Afbranden van terreinen, bermen e.d.		C9
Onbekend		C12

B.4.2 New South Wales

Building fire incidents in Australia's New South Wales report [4] are listed in Table 23 by cause and occupancy. Values in Tables 3-2 and 3-3 of this report reflect reclassification of that Table 23 information as indicated below in Table B-3.

B.4.3 United Kingdom

Building fire incidents in United Kingdom reports [6] are listed for 1979 in Table 39 by cause and occupancy, and in Table 23 by occupancy. Non-building fires are classified in Table 44. The occupancy classification of Table 23 is somewhat more detailed than that of Table 39. Thus, in some cases, marginal subtotals were developed for occupancy classifications of Tables 3-2 and 3-3 in this report, even though a cause breakdown was impossible. Similarly, when some, but not all incidents of an occupancy group were classified by cause, others were distributed proportionately. Details of all reclassifications are provided in Table B-4 below.

TABLE B-3. NEW SOUTH WALES CLASSIFICATION

(a) Cause

C4	Incendiarism/Suspicious Circumstances
C11	Fireworks
C2	Smoking in Bed, etc.
C7	Matches/Cigarettes (under 16 yrs)
C2	Matches/Cigarettes (Other)
C11	Re-ignition of Fire
C8	Campfire, barbecue in the open
"	Burning rubbish, waste
"	Burning bush, scrub, grass
"	Burning on demolition site
"	Incinerator
"	Other controlled fire in open
"	Fixed Open Fireplace
"	Portable Open Fireplace
C3	Fixed Electric Radiator, Defective
"	Portable " " , "
"	" " " , Upset
"	Fixed " " , Other
"	Portable " " , "
"	Fixed Gas Fire, Defective
"	Portable Gas Fire, "
"	" " " , Upset
"	Fixed " " , Other
"	Portable " " , "
"	Fixed Kero, Radiator, Defective
"	Portable Kero " , "
"	" " " , Upset
"	Fixed " " , Filling
"	Portable " " , "
"	Fixed " " , Other
"	Portable " " , "
"	Oil Heater, Fixed, Defective
"	" " , Portable, "
"	" " , Upset, Portable
"	" " , Other, Fixed
"	" " , " , Portable
"	Other Room and Space Heating, Fixed
"	" " " " " , Portable
C1	Electric Oven/Stove, Defective
"	" " " , Overheating Foodstuff
"	Electric Oven/Stove, Other
"	Gas Oven/Stove, Defective
"	" " " , Overheating Foodstuff
"	Gas Oven/Stove, Other
"	Other Cooking Appliance, Defective
"	" " " , Overheating Foodstuff
"	Other Cooking Appliance, Other

(b) Occupancy

Dwelling House	R1
Flat, Home Unit, etc.	R2
Group Accommodation	R4
Office	N4
Cafe, Restaurant	N1
Other Retailing	N4
Metal Manufacture	N6
Food and Drink Manufacture	N6
Brickworks, Glass, Chemical, Rubber, and Plastic Manufacture	N5
Wood Products Manufacture	N6
Paper Products Manufacture	N6
Textile Manufacture	N6
Other Manufacture (incl. Power Station)	N5
Public Assembly Building (incl. Club)	N1
Educational Institution	N2
Other Institutional Building	N3
Wholesale and Bulk Storage; Other Miscellaneous Structure	N7
Minor Ancillary Building and Unclassifiable Unoccupied Building	N8

(a) Cause (Continued)

C3	Defective Hot Water Service, Gas
"	" " " " , Oil
"	" " " " , Electric
"	" " " " , Other
"	Hot Water Service, Other than Defective
C11	Industrial Heat Production System, Boiler, Electric
"	Industrial Heat Production System, Boiler, Oil
"	Industrial Heat Production System, Boiler, Other
"	Industrial Heat Production System, Furnace, Electric
"	Industrial Heat Production System, Furnace, Gas
"	Industrial Heat Production System, Furnace, Oil
"	Industrial Heat Production System, Furnace, Other
"	Industrial Heat Production System, Other, Electric
"	Industrial Heat Production System, Other, Gas
"	Industrial Heat Production System, Other, Oil
"	Other Appliance Designed for Heat Production
C8	Blow Lamp
"	Welding and cutting equipment
"	Other Hand Tool
C6	T.V. - black and white
"	T.V. - colour
"	Electric blanket
"	Refrigerator (incl. freezer)
"	Washing Machine, Electric
"	Clothes Dryer, Electric
"	Other domestic appliance, n.e.c.
C11	Electric lighting fixture
C6	Electric fan
C11	Electric Motor, n.e.c.
"	Other Motor, n.e.c.
C5	Conveyor and power transmission
C11	Other Industrial Appliance, n.e.c.
C11	Telephone Equipment
"	Electric photo-copy machine
"	Other, Tools, Equipment, n.e.c.
C5	Overloading Electrical Circuit
"	Wiring from outlet to appliance
"	Wiring of building
"	Switchboard/Switchgear
"	Other electrical supply equipment
C11	Transport, crash or collision
"	Transport, electrical fault
C8	Sparks from transport, including locomotive, tractor -
C11	Transport, filling fuel tank
"	Transport, Other
"	Ignition of flammable substance during manufacture, n.e.c.
"	Flammable substance, storage of, n.e.c.
"	Fuel supply line, n.e.c.
"	Fat, cooking oil, n.e.c.
"	Other hot substance, n.e.c.
C8	Chimney exhaust
"	Flue exhaust
"	Duct exhaust
"	Other exhaust system
C10	Spontaneous combustion
"	Lightning
"	Static Electricity
"	Other natural cause
C5	Naked Light
C11	Explosion, n.e.c.
"	Other known cause
C12	Unknown cause
	Total, All Causes

TABLE B-4. UNITED KINGDOM CLASSIFICATION

(a) Occupancy - Buildings

Dwellings	
Single occupancy	R1
Multiple occupancy	R2
Other and unrecorded	R3
Private occupancies (non-residential)	N9
Agricultural, forestry, fishing premises	N5
Mining and quarrying premises	N5
Manufacturing industry premises	
Food, drink and tobacco	N6
Coal and petroleum products	N5
Chemical and allied industries	N6
Metal manufacture	N6
Mechanical engineering	N4
Instrument engineering	N4
Electrical engineering	N4
Shipbuilding and marine engineering	N6
Vehicles	N6
Metal goods not elsewhere specified	N6
Unknown metal goods	N6
Textiles	N6
Leather, leather goods, fur	N6
Clothing and footwear	N6
Bricks, pottery, glass, cement etc	N6
Timber, furniture etc	N6
Paper, printing and publishing	N6
Other manufacturing industries	N6
Construction industry premises	N8
Gas, electricity and water premises	N5
Transport and communication premises	N5
Distributive trade premises	N4
Wholesale	N4
Dealers	N4
Retail	N4
Insurance, banking, finance, business service premises	N4
Professional and scientific service premises	
Schools	N2
Hospitals – psychiatric	N3
– non-psychiatric	N3
Other professional and scientific services	N4
Miscellaneous service premises	
Places of public entertainment and ancillary services	N1
Hotels	R4
Hostels, boarding houses, holiday camps etc	R4
Cafes, restaurants etc	N1
Clubs, public houses etc	N1
Elderly persons' homes	N3
Orphanages, homes for disabled or handicapped	N3
Other miscellaneous services	N9
Public administration and defence premises	N4
Other	N9
Unrecorded	N9

TABLE B-4. UNITED KINGDOM CLASSIFICATION

(b) Cause

Children with fire	C7
Malicious or doubtful	C4
Smokers' materials	C2
Matches	C2
Cooking appliances	C1
Electric	
Gas (mains)	
Liquefied petroleum gas	
Solid fuel	
Other and unrecorded fuel	
Space heating	C3
Electric	
Gas (mains)	
Liquefied petroleum gas	
Solid fuel:	
Fire in grate	
Slow combustion stove	
Other	
Oil and petroleum	
Other and unrecorded fuel	
Central heating installations	C3
Electric	
Gas (mains)	
Solid fuel	
Oil and petroleum	
Other and unrecorded fuel	
Water heating installations	C3
Electric	
Gas (mains)	
Other and unrecorded fuel	
Welding and cutting appliances	C8
Electric	
Acetylene	
Other and unrecorded fuel	
Blowlamps	C8
Liquefied petroleum gas	
Oil and petroleum	
Other and unrecorded fuel	
Other electrical equipment	
Electrical wiring	C5
Washing machine, dishwasher	C6
Lighting	C5
Blanket, bedwarmer	C6
Television	C6
Radio	C6
Refrigerator	C6
Other	C11
Other appliances and installations fuelled by:	
Gas (mains)	C8
Liquefied petroleum gas	C8
Solid fuel	C11
Oil and petroleum	C11
Other and unrecorded fuel	C11
Ashes, soot	C8
Chimney, stove pipe, flue (not confined to)	C3
Explosives, fireworks	C11
Naked light, taper, candle etc	C11
Natural occurrences	C10
Rubbish burning	C8
Spontaneous combustion	C10
Other	C11
Unknown	C12

TABLE B-4. UNITED KINGDOM CLASSIFICATION

(c) Occupancy Non-Building

Derelict buildings	N5
Outdoor storage	O5
Outdoor machinery and equipment	
Electrical supply plant	N5
Gas works plant and mains	N5
Tar boilers, tar plant	M4
Agricultural machinery	M4
Roadmaking and earth moving machinery	M4
Other mobile equipment	M4
Other fixed equipment	O5
Road vehicles	
Cars, estate cars, land rovers	M1
Vans	M2
Motor cycles, motor scooters	M2
Tankers	M2
Other lorries	M2
Coaches, omnibuses, minibuses	M2
Other vehicles	M2
Caravans	R3
On site	
Other	
Ships and boats	M3
On inland waterways	
In port or dock or on dry land	
Other	
Railway rolling stock	M3
Aircraft	M3
Letter boxes	O5
Crops and agricultural locations(1)	O4
Woods, forests, plantations, orchards	O3
Allotments, gardens, nurseries	O2
Grasslands	O5
Refuse	O1
Other	O5
Unrecorded	O5

APPENDIX C

SOURCES OF INTERNATIONAL FIRE STATISTICAL INFORMATION

A comprehensive survey of potential information providers was undertaken to develop the comparisons presented in this document. The survey was accomplished by letters to potential respondents requesting data, followed by additional letters as required. Some of the responses were negative, viz., they did not have the data for the time period or in the format requested. Some of the requests were returned as "addressee unknown at this location." Still, other requests went unanswered. Finally, those that provided statistics on fires are indicated in the listing which follows:

1. Ing. J. Kaiser
   Zentralstelle Für Brandverhutüng
   A-1030 Wien 3
   Schwarzenbergplatz 7
   AUSTRIA

2. J. J. Keough, Manager
   Fire Research
   Department of Construction
   Experimental Building Station
   87-101 Delhi Road
   North Ryde, N.S.W.
   AUSTRALIA

3. John N. Cardoulis, Fire Commissioner
   Pleasantville Fire Station
   Building 901
   Pleasantville
   St. John's Newfoundland
   AIC 5T7
   CANADA

4. G. A. Hope
   Dominion Fire Commissioner
   Public Works Canada
   Immeuble Sir Charles Tupper Bldg.
   Prom. Riverside Drive
   Ottawa KIA 0M2
   CANADA

5. Joyce Parker
   Fire Statistician
   Office of the Fire Marshall
   P.O. Box 6000
   Frederickton, NB
   E3b 5H1
   CANADA

6. Richard Shephard
Office of the Fire Marshal
Department of Labour and Manpower
P.O. Box 697
Halifax, N.S.
CANADA

7. Arthur Taxiaux
Chef de Division
Service de la prévention
Government du Québec
Ministére des Affaires Muncipales
Direction Général de la Prévention des Incendies
20, Chauveau, Quebec
GIR 4Y6
CANADA

8. Leif Bastiansen, Dep. Man.
Danish Insurance Information Office
Forsikringsoplysningen
10 Amaliegade
1256 Kobenhaven K
DENMARK

9. Dr. E. J. Denney
Chief Technical Officer
Fire Protection Association
Aldermary House
Queen Street
London E. C. 4
City 5222
ENGLAND

10. Andy O'Flynn
British Insurance Association
Aldermary House, Queen Street
London,
EC4N 1TU
ENGLAND

11. R. H. French
Assistant Secretary
British Insurance Association
Aldermary House
Queen Street
London
EC4N 1TU
ENGLAND

12. Basil H. Mahon, Head
53 Division
Home Office
Queen Anne's Gate
London
SW1H 9AT
ENGLAND

13. G. Rieutord
Ministere de L'Interieur et de la Decentralisation
Direction de la Securite Civile
Sous-Direction de la Prevention et des Etudes
Bureau de la Documentation, des Statistiques et de l'Informatique
1, Place Beauvau
75800-Paris
FRANCE

14. Alfons Orth
dfv
Postfach 200269
d-5300 Bonn 2
GERMANY (F.R.)

15. Seiden, Chief Fire Officer
Berliner Feuerwehr
Nikolaus-Grob-Web 2
1000 Berlin (West) 13
GERMANY (F.R.)

16 Dr. H. P. Sterk
Verband der Sachveisickerer e. V. Kӧln
5000 Koln-1 Riehler Strabe 36
Postfach 10 20 24
GERMANY (F.R.)

17. Leo Connell
Department of the Environment
Custom House
Dublin, 1
IRELAND

18. Capt. C. I. Garvey
Chief Fire Officer
Cork Corporation Fire Dept.
Angelsea Street
Cork
IRELAND

19. J. Kelly
Fire Services Section
Department of the Environment
Custom House
Dublin, 1
IRELAND

20. Dott. Ing. Sergio Urbani, Direttore
Concordato Italiano Incendio
Riochi Industriali
Fondato Nel 1883
20122 Milano
ITALY

21. Haruo Ohno, Chief Liaison Branch
Tokyo Fire Department
3-5, Otemachi 1 Chome
Chiyoda Ku
Tokyo, 100
JAPAN

22. B. M. Van Der Harst, Librarian
Department for Criminal and Judicial Statistics
Netherlands Central Bureau of Statistics
Princes Beatrixlaan 428, Postbus 959
2270 AZ Voorburg
THE NETHERLANDS

23. J. G. S. J. Van Maarseveen, Head
Department for Criminal and Judicial Statistics
Netherlands Central Bureau of Statistics
Prinses Beatrixlaan 428, Postbus 959
2270 AZ Voorburg
THE NETHERLANDS

24. Dr. Evert C. Wessels
TBBS
EEMNESSERWEG 56
3740 ab Baarn
Postbus 54
THE NETHERLANDS

25. Dennis Bastings, Head
Fire Research Division
Building Research Association of New Zealand
Private Bag
Porirua
NEW ZEALAND

26. A. Rydning
Norges Brannkasse
Postboks 1045 Sentrum
OSLO 1
NORWAY

27. Hans Lagerhorn
SBF
The Swedish Fire Protection Association
Kungsholms Hamnplan 3
112 20 Stockholm
SWEDEN

28. Dr. W. Lindenmann
BVD-SPI
Nuschelerstrasse 45
CH-8001
Zürich
SWITZERLAND

29. Henry Tovey
Federal Emergency Management Agency
Washington, D.C. 20472
UNITED STATES

INFLUENCE OF GEOGRAPHIC AND SOCIO-ECONOMIC FACTORS ON FIRE DEATH RATES

INFLUENCE OF GEOGRAPHIC AND SOCIO–ECONOMIC FACTORS ON FIRE DEATH RATES

By

Douglas C. Montgomery

Jerry Banks

GEORGIA INSTITUTE OF TECHNOLOGY

Atlanta, Georgia 30332

With the Support of the
Federal Emergency Management Agency
Contract No. EMW–C–0655

December 1982

EXECUTIVE SUMMARY

This report relates fire death rates to a number of candidate factors such as per capita alcohol consumption, per capita cigarette consumption, percent minority population, housing quality index and educational attainment index. Three natural experiments were conducted to test a set of hypotheses. Within the limits of statistical significance, a number of statements can be made:

- It appears that there is a significant difference in fire death rates for warm and cold climates, with the latter of the two having the higher rate.
- Within regions having a cold climate, per capita alcohol consumption has the most influence on the fire death rate of any factor examined. Per capita cigarette consumption and the number of fire fighters per capita are also influential on the fire death rate.
- The percent white population and the quality of housing were found to be highly significant in explaining the fire death rate.

The tool used for analysis is multiple linear regression, a statistical procedure for modeling and investigating the relationships between variables in the setting of a natural experiment. A natural experiment uses data as it arises in nature as opposed to controlling the data as occurs in a designed experiment. By way of example, cigarette consumption cannot be controlled, but we have access to such information.

INTRODUCTION

The objective of this research is the identification of factors that can help to explain the fire death rate. Multiple regression analysis is used to investigate the relationships between fire death rates and several independent or regressor variables that may have predictive or explanatory value. The data arise in the setting of natural or unplanned experiments. In each of the natural experiments, we selected a hypothesis to be investigated, obtained an appropriate data base, and then structured a linear regression model that attempted to identify the relationships between the independent variables and the fire death rate. Inferences were obtained through hypothesis testing on the parameters in the resulting regression model.

The report is organized in the following manner. First, we summarize the major findings. Then we discuss our methodology. Next, we give a brief description of the variables in the data base and some information on data sources. Next we mention several similar studies. We then describe the three natural experiments and explain the results. We conclude the report with some insights and comments gained during the research.

FINDINGS

Three natural experiments are presented in this report. The first experiment investigates the effect of cold climates with the associated intensive heating on the fire death rate. There is a statistically identifiable increase in the fire death rate when changing from a warm weather to a cold weather climate. Also, of high significance in this experiment were the technology and educational levels of the population.

The second experiment blocked out the effect of cold weather by analyzing data from regions having similar cold weather climates. Per capita alcohol consumption emerged as the most important variable in the model. The next two highest variables in order of importance were per capita cigarette consumption and the number of fire fighters per capita.

The third experiment uses data from the 48 contiguous states to investigate the hypothesis that the percent of minority population is related to fire death rates. The resulting model has the highest explanatory value of the three in this report. The percent white in the population did emerge as the most significant variable of nine candidates. Also of nearly the same significance was the percent of houses with all plumbing.

METHODOLOGY

Suppose that y represents the response variable of interest, such as fire deaths, fire incidents, or property damage. We assume that data is available in several environmental settings that are similar in at least one important characteristic. For example, two similar enviornmental settings might be Alaska and North Dakota. The similarity of these two environments is that both have persistent cold weather and are sparsely populated. Let $x_1, x_2, \ldots, x_{k-1}$ be a set of factors whose effect on fire losses we wish to investigate. Possible factors would include such variables as population density, the percent of the population that is rural, per capita income, per capita alcohol consumption, the percent of the housing stock that is substandard, percent of the population that is non-white, and so forth. An important practical problem associated with these natural experiments is the identification of factors such as these which must be investigated. In many cases, the type of experiments that can be performed will be limited by the availability of this data.

A multiple linear regression model relating the response variable y to the regressor variables $x_1, x_2, \ldots, x_{k-1}$ is

$$y = \beta_0 + \sum_{j=1}^{k} \beta_j x_j + \varepsilon$$

where x_k is an indicator variable that categorizes the two environmental settings of interest. In this example, the indicator variable would be defined as follows:

$$x_k = \begin{cases} 0 \text{ if the observation is from North Dakota} \\ 1 \text{ if the observation is from Alaska} \end{cases}$$

Standard linear least squares methods may be used to fit this model, assuming that yearly data from each location on each of the response and regressor variables is available.

To test the contribution of any factor to the model we would test the hypothesis:

$$H_0: \ \beta_j = 0$$

$$H_1: \ \beta_j \neq 0$$

for j =1, 2,..., k. This can be done using the standard partial F test or "extra sum of squares" method. The test on β_k is a test of the "state" effect; if this hypothesis is not rejected it implies that the two regression planes are coincident, that is, there is no difference between states. The least squares regression coefficient β_j is a point estimate of the effect of the variable x_j on fire losses (conditional on the other x's remaining constant) and a 100(1-α) percent confidence interval on this effect is

$$\beta_j \neq t_{\alpha/2,\ n-p}\ se(\beta_j)$$

where $se(\beta_j)$ is the standard error of β_j and p = k+1 is the number of unknown regression coefficients.

The above experimental procedure assumes that reasonable data is available across several years, perhaps as many as 20 or 25 years. In many situations, it is unrealistic to expect that this kind of data will exist. Furthermore, some of the variables of interest, such as population, will change very slowly, and we anticipate that this could restrict the use of the type of methodology that we have described.

It is possible however, to still use regression methodology in situations where only a limited amount of yearly data exist. Rather than using a longitudinal type of approach, it is possible to adopt a latitudinal modeling technique. This would require that a relatively large number of different sites be available, and that data for only one or two years be used. Considering the extent and availability of data, this type of experiment would be most common.

If one wished to investigate the effect of cold weather on the occurrence of fire deaths, it would be possible to select a number of different geographical settings such that the factor "climate" could be investigated. For example, say ten countries in warm climates and ten countries in cold climates could be identified, along with relevant statistical data concerning regressor variables of interest, the response variable, and an indicator variable to separate warm weather and cold weather countries could be identified. Then a modeling approach very similar to that adopted above could be used. In this model, the regression coefficient identified with the indicator variable for climate would be a measure of the effect on mean death rate of changing from a warm weather to a cold weather environment. If this coefficient was statistically significant at an appropriate level, then that would be an indication that climate does in fact have an effect on the occurrence of fire deaths. Similarly, if the coefficient was not statistically significant, then there would be no evidence in the data to support the hypothesis that warm weather and cold weather climates have different effects on the occurrence of fire deaths.

Note that, in this situation, the coefficient in question, say β_j, is the coefficient of an indicator variable. Thus, β_j really measures how far apart the two regression planes are for the warm weather and cold weather climates, respectively. It is still a partial regression coefficient, and its estimator depends on the other x's in the model.

Notice that regression models can be used in two different contexts: latitudinal studies and longitudinal studies. Because of the availability of data, and the fact that the data often changes very slowly over years, we suspect that latitudinal type studies will be most frequently conducted. Considering the relevancy of current data as compared to older data, it may also be the case that these latitudinal studies are of more technical interest.

DATA BASE

We now give a brief description of the variables in the data base and some information on data sources.

Fire Death Rate. Deaths due to fire per one million population. This data is taken from the publication "Fire in the United States," U.S. Department of Commerce, U.S. Fire Administration, National Fire Data Center, December, 1978.

Urban Population. Percentage of population living in urban areas. This data is taken from the WORLD ALMANAC AND BOOK OF FACTS, 1982.

White Population. Percent of population that is white. This data is taken from the WORLD ALMANAC AND BOOK OF FACTS, 1982.

Income. Per capita income for 1980. This data is taken from the WORLD ALMANAC AND BOOK OF FACTS, 1982.

Cigarette Consumption. Per capita cigarette consumption. This data is taken from the "Annual Report on Tobacco Statisitcs," 1980, U.S. Department of Agriculture, and from the "Agricultural Marketing Service, Statistical Bulletin No. 667," May 1981. The method of calculation is given by the following relationship:

$$\frac{\text{Cigarette Sales Tax Collected/Cigarette Sales Tax Rate}}{\text{Population}}$$

Alcohol Consumption. Per capital alcohol consumption of absolute alcohol in gallons. This data is taken from the "First Statistical Compendium on Alcohol and Health," U.S. Department of Health and Human Services, February, 1981.

Housing Index. Percent of houses with all plumbing. This data is taken from STATISTICAL ABSTRACT OF THE UNITED STATES, 1981, U.S. Department of Commerce.

Open Flame Heating. This is a zero/one variable. A one represents a dominance of open flame heating and a zero represents the complement.

Technology Index. This is a function of the number of television sets and telephones in the state. The data is taken from the STATE METROPOLITAN AREA DATA BOOK, 1979 and from the STATISTICAL ABSTRACT OF THE UNITED STATES, 1981. The index is determined by the following relationship:

$$\frac{\text{Per Capita TV Sets}}{\text{Average Per Capita TV Sets}} + \frac{\text{Telephones/100 of Population}}{\text{Average Telephones/100 of Population}}$$

Fire Fighters. The number of fire fighters per 1,000 persons. This data is taken from surveys conducted by the Tokyo Fire Department.

Fire Equipment. Number of pieces of fire fighting equipment per 1,000 persons. This data is taken from surveys conducted by the Tokyo Fire Department.

Minority Population. Percent minority in population. This data is taken from the WORLD ALMANAC AND BOOK OF FACTS, 1982, and from the NATIONAL ATLAS OF CANADA, 1974.

Education Index. Education obtainment in years completed. This data is from the STATISTICAL YEARBOOK OF THE UNITED NATIONS, Educational Scientific Cultural Organization, 1980, and from the DIGEST OF EDUCATIONAL STATISTICS, 1981.

GNP. Gross National Product data are for the year 1979 and mostly from, "Foreign Economic Trends and Their Implications for the United States," a semi-annual publication of the U.S. Department of Commerce.

Indicator. This is a zero/one variable. A zero indicates that the geographical region has a warm weather climate and a one is the complement.

NATURAL EXPERIMENTS

Using the data base described above, three natural experiments are presented. The first experiment investigates the effect of cold climates with the associated intensive heating on the fire death rate. The second example blocks out the climatic effect by analyzing data from cold climates only and examines the joint effects of alcohol consumption and cigarette consumption on fire death rates. The third experiment involves data from the 48 contiguous states and examines the effect of minority population on the occurence of fire deaths. All of these hypotheses are of direct concern to fire researchers.

Experiment 1. Comparison of Warm Versus Cold Climates.

This experiment tests the hypothesis that the incidence of deaths from fires is greater in cold weather climates than in warm ones. To investigate this hypothesis, data from twenty countries on the variables Fire Death Rate, Urban Population, Technology Index, Gross National Product, Housing Index, Alcohol Consumption, and Education Index, were selected. The countries included in the study were Austria, Belgium, Canada, Czechoslovakia, Denmark, Finland, France, East Germany, West Germany, Greece, Hungary, Italy, The Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, The United Kingdom, and the United States. The countries of Greece, Italy, Portugal, and Spain were identified as having warm climates, distinctly different from the others. Therefore, this study involved four sites with warm weather climates and sixteen sites with cold weather climates.

Table 1 presents the mean, standard deviation, coefficient of variation, and the minimum and maximum values for each of the variables used in the study. Table 2 contains the corresponding correlation matrix. The entries in the body of this table are the correlations between the variables identified in the row and columns. Recall that correlation is a measure of linear association that varies over the interval -1 to +1. A correlation coefficient near either +1 or -1 implies that the two variables are nearly perfectly linearly related. Values approaching +1 indicate direct relationship, and approaching

TABLE 1. INPUT DATA (EXPERIMENT 1)

VARIABLE	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION	MINIMUM	MAXIMUM
Fire Death Rate	13.335	7.21437	.54101	3.89	30.53
Urban Population	68.545	12.56115	.18325	44.2	94.6
Technology Index	3.16785	1.61441	.50962	.960	8.205
Gross National Product	7358.15	3017.38479	.41007	1913	12945
Housing Index	3.13805	.90425	.28816	1.435	4.384
Alcohol Consumption	13.004	4.52032	.34761	5.58	23.76
Education Index	6.6885	1.99879	.29884	2.63	9.9

Dimensions of variables on all tables are as explained in section entitled DATA BASE beginning on page 6.

TABLE 2. CORRELATION MATRIX (EXPERIMENT 1)

VARIABLE	FIRE DEATH RATE	URBAN POPULATION	TECHNOLOGY INDEX	GROSS NATIONAL POPULATION	HOUSING INDEX	ALCOHOL CONSUMPTION	EDUCATION INDEX
FIRE DEATH RATE	1.0000						
URBAN POPULATION	-.0582	1.0000					
TECHNOLOGY INDEX	.4280	.2607	1.0000				
GROSS NATIONAL PRODUCT	-.1087	.1402	.5911	1.0000			
HOUSING INDEX	.0809	.0127	.7239	.6430	1.0000		
ALCOHOL CONSUMPTION	-.0600	.0274	-.4579	.4007	-.4275	1.0000	
EDUCATION INDEX	.3629	.2237	.6441	.5252	.4496	-.6478	1.0000

-1 indicates inverse relationship. It should be noted that there are some moderately high correlations among the candidate regressor variables and the fire death rate. In particular, Technology Index and Education Index have individual simple correlations of .4280 and .3629, respectively. This would imply that possibly a satisfactory regression model could be found by relating these variables to the Fire Death Rate. The zero/one Indicator variable was included in the regression model to account for the warm weather and cold weather climates. Table 3 summarizes the regression results.

The upper part of Table 3 gives measures from the analysis of variance. The total variability in the data is divided into components due to regression (variability explained by the model) and residual (variability unexplained by the model). The F ratio is a test of the hypothesis that the fire death rate is linearly related to at least one of the regression variables in this model. The significance level is the probability of rejecting a true hypothesis. In Table 3, the value 0.04669 indicates a low probability of rejection, or a statistically significant result.

The middle part of Table 3 displays the variables, the corresponding regression coefficient, the standard error of the estimate for the coefficient, which is a measure of the precision of estimation (small standard errors imply a precise estimate), the t statistic for testing the hypothesis that the coefficient equals zero, and the significance level for the t test. Note that small probabilities imply highly significant results. This latter test is important, because it measures the contribution of individual variables to the model, adjusted for the effects of all others.

TABLE 3. REGRESSION SUMMARY STATISTICS (EXPERIMENT 1)

	SUM OF SQUARES	DEGREE OF FREEDOM	MEAN SQUARE	F RATIO	SIGNIFICANCE LEVEL
REGRESSION	572.639	6	95.44	2.981	.04669
RESIDUAL	416.257	13	32.02		

VARIABLE	REGRESSION COEFFICIENT	STANDARD ERROR	t STATISTIC	SIGNIFICANCE LEVEL
Intercept	11.10572			
Urban Population	-.18772	.114	-1.646	.124
Technology Index	3.81265	1.423	2.679	.019
Gross National Product	-.00123	.001	-2.037	.063
Housing Index	-2.26744	2.387	-.950	.360
Alcohol Consumption	.53985	.394	1.369	.194
Education Index	1.81446	1.042	1.741	.105
Indicator	1.71246	.984	1.740	.105

MULTIPLE R^2 .5791

The last entry in Table 3 is the multiple R^2. Its value is about .58, indicating that approximately 58% of the variability in the fire death rate can be explained as a result of the regressor variables chosen in this model. All of the regressor variables are significant at least the 20% level, with the exception of the Housing Index, which is only significant at about the 36% level. The Indicator variable corresponding to the climate factor is significant at about the 10% level. The positive coefficient of this variable indicates that changing from a warm weather to a cold weather climate increases the mean fire death rate by 1.71246, given the other x's in the model. In other words, the mean fire death rate differs by 1.71246 assuming that the other regressor variables are considered simultaneously. Therefore, one could conclude from this analysis that there is a statistically identifiable effect of cold weather climates on the fire death rate.

Table 4 presents the residuals, the predicted value of the fire death rate, and the observed value of the fire death rate for the twenty countries included in the study. The residuals are calculated as the difference between the observed and the predicted responses, and are an important measure of the adequacy of the model. Notice that the predicted and observed responses are close in magnitude. The largest residual is for Canada. If this residual was larger than twice the square root of the residual mean square, then the observation for Canada may be "unusual," that is, it may be an outlier. However, the value of this residual is less than $2\sqrt{32.02} = 11.32$, so there is no strong

TABLE 4. RESIDUALS, PREDICTED AND OBSERVED FIRE DEATH RATES (EXPERIMENT 1)

COUNTRY	RESIDUAL	PREDICTED RESPONSE	OBSERVED RESPONSE
Austria	2.0102	7.1698	9.18
Belgium	5.3695	7.0305	12.40
Canada	10.8559	19.6741	30.53
Czechoslovakia	-3.5063	15.8463	12.34
Denmark	-2.5220	12.2920	9.77
Finland	-.8031	17.9531	17.15
France	-1.4245	15.7445	14.32
East Germany	-5.2494	11.3194	6.07
West Germany	1.1800	7.4800	8.66
Greece	1.1584	13.2516	14.41
Hungary	2.7857	16.2643	19.05
Italy	-4.1229	9.9229	5.80
Netherlands	-6.0892	9.9792	3.89
Norway	3.1137	12.5363	15.65
Portugal	7.1553	14.3947	21.55
Spain	-7.1433	14.6533	7.51
Sweden	4.0352	9.8048	13.84
Switzerland	-3.8425	9.0425	5.20
United Kingdom	.0573	11.3427	11.40
United States	-3.0180	30.9980	27.98

indication that it is an outlier. Figures 1 and 2 present the plot of residuals versus the predicted values, and a normal probability plot of the residuals, respectively. The plot of residuals versus predicted values should be structureless, and the normal probability plot should be approximately a straight line, implying that the residuals are a sample from a normal distribution. Neither of these plots exhibit any unusual behavior. Therefore, we conclude that there is no reason to doubt the adequacy of the fitted model. It would be desirable to find a model that explained a higher percentage of total variability in the death rate data, but that would involve finding a different set of candidate regressor variables for use in the model.

Experiment 2. Blocking Out Cold Weather.

In Experiment 1, we demonstrated that there was a significant effect of cold weather on the fire death rate. We would now like to block out the effect of cold weather, and study other environmental and sociological factors which might influence the fire death rate. In order to do this, we selected 32 locations. These locations are 13 northern states of the United States, 9 Canadian provinces, and 10 European countries. These locations were selected as being of similar geographical size and population, and having comparable climates.

Table 5 shows the input data on the variables used in this study. Table 6 shows the correlation matrix between all of the candidate regressors and the response. A number of variables are highly correlated with the fire death rate. Note particularly the correlation for Technology Index (.3807), Fire Fighters (.7026), Education Index (.5780), and Cigarette Consumption (.5378).

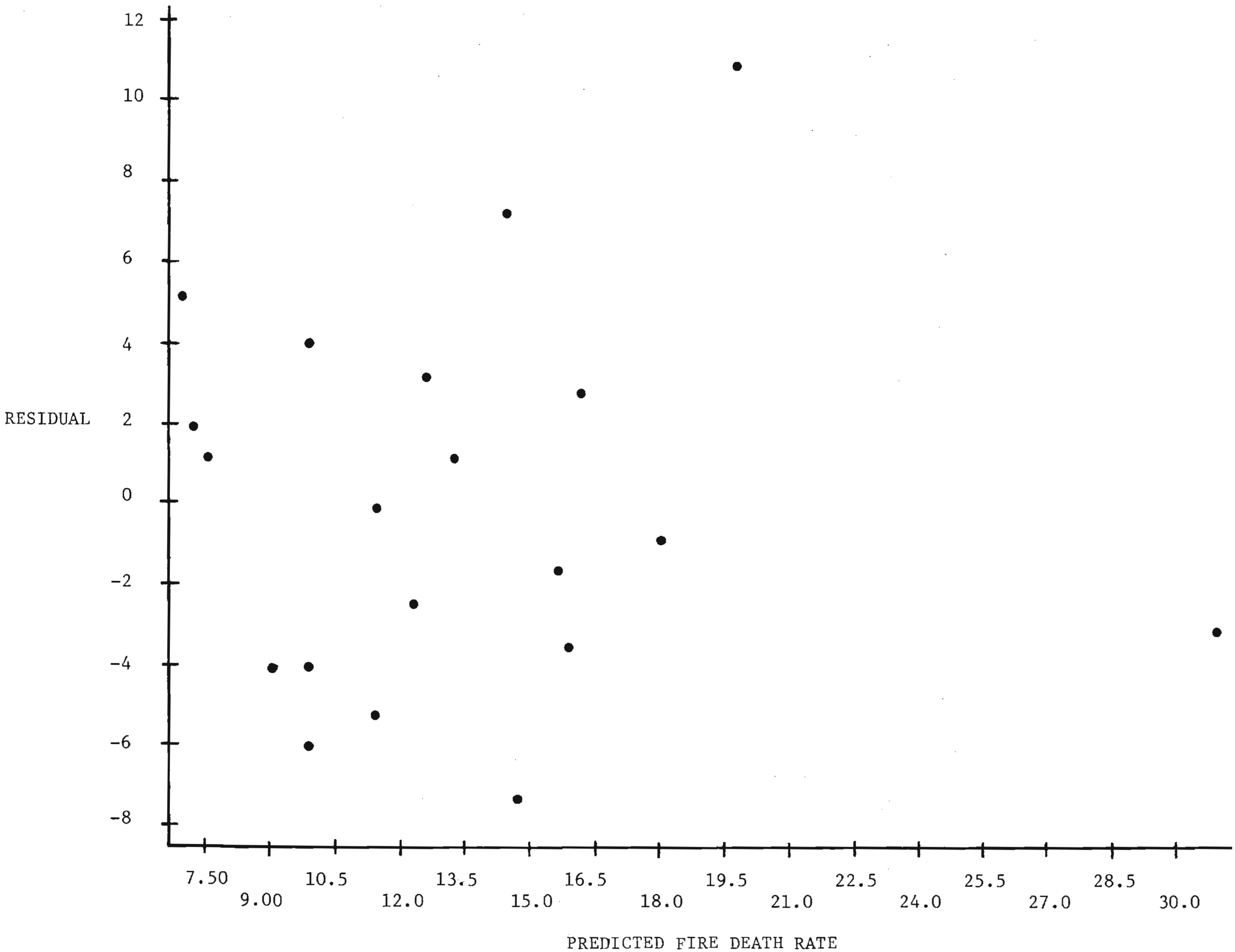

FIGURE 1. PLOT OF RESIDUALS VS. PREDICTED FIRE DEATH RATE (EXPERIMENT 1)

TABLE 6. CORRELATION MATRIX (EXPERIMENT 2)

	FIRE DEATH RATE	ALCOHOL CONSUMPTION	URBAN POPULATION	MINORITY POPULATION	INCOME INDEX	TECHNOLOGY INDEX	FIRE FIGHTERS	FIRE EQUIPMENT	OPEN FLAME HEATING	CIGARETTE CONSUMPTION	EDUCATION INDEX	HOUSING INDEX
FIRE DEATH RATE	1.0000											
ALCOHOL CONSUMPTION	.0983	1.0000										
URBAN POPULATION	-.3101	-.2269	1.0000									
MINORITY POPULATION	.2464	.2123	.3618	1.0000								
INCOME INDEX	-.1722	.3718	.3515	.3618	1.0000							
TECHNOLOGY INDEX	.3807	.7216	-.2035	.4893	.4587	1.0000						
FIRE FIGHTERS	.7026	.4431	-.2890	.3883	.1293	.7016	1.0000					
FIRE EQUIPMENT	.2195	.6395	-.2274	.2257	.3077	.8183	.5095	1.0000				
OPEN FLAME HEATING	-.0479	-.1424	-.3612	-.3222	-.1666	-.0869	-.1673	-.0160	1.0000			
CIGARETTE CONSUMPTION	.5378	.6998	-.1911	.3488	.1656	.6912	.7197	.3977	-.0911	1.0000		
EDUCATION INDEX	.5780	.4410	-.1173	.4585	.2824	.7118	.7883	.4905	-.1266	.7181	1.0000	
HOUSING INDEX	.2553	.2608	.0426	.2070	.2027	.2810	.3573	.2170	.1743	.4963	.3515	1.0000

Table 7 shows the regression results. The multiple R^2 for this model is .6619. That is, the model explains approximately 66% of the variability in the fire death rate. Examining the t statistics and the significance probabilities, we notice that a number of variables are highly influential in their impact on the fire death rate. Alcohol Consumption emerges as the most important single variable, followed by Cigarette Consumption and then Fire Fighters.

Table 8 presents the residuals, the predicted values of the fire death rate and the observed values of the fire death rate for this model. The only unusually large residual is for New Brunswick, and this residual exceeds 3 standard deviations. It is possible that this data point is an outlier. It may be a recording or transmission error, or erroneous in some other regard. However, further examination did not imply that the data point could be arbitrarily removed from the model, so it was decided to leave this observation in the data set.

Figure 3 is a normal probability plot of the residuals. The unusual observation for New Brunswick is clearly evident on this graph. However, the remaining residuals plot approximately along a straight line, and so we conclude that there is no serious reason to doubt the normality assumption. However, we do suspect that there is some discrepancy with the New Brunswick observation.

Experiment 3. Minority Population.

This experiment investigates the effect of a signficant minority population on the incidence of the fire death rate. The data were collected from the 48 contiguous states and is summarized in Table 9. The variable of primary interest in the study is White Population. It

TABLE 7. REGRESSION SUMMARY STATISTICS (EXPERIMENT 2)

	SUM OF SQUARES	DEGREE OF FREEDOM	MEAN SQUARE	F RATIO	SIGNIFICANCE LEVEL
REGRESSION	3169.719	11	288.156	3.560	.00668
RESIDUAL	416.257	13	32.020		

VARIABLE	REGRESSION COEFFICIENT	STANDARD ERROR	t STATISTIC	SIGNIFICANCE LEVEL
Intercept	20.04842			
Alcohol Consumption	-9.74755	4.989	-1.954	.065
Urban Population	-.18340	.173	-1.060	.302
Minority Population	.30784	.568	.542	.594
Income	-4.45890	11.728	-.380	.708
Technology Index	-1.15713	3.661	-.316	.755
Fire Fighters	11.74902	7.932	1.481	.154
Fire Equipment	108.51140	179.768	.604	.553
Open Flame Heating	-1.81597	4.560	-.398	.695
Cigarette Consumption	17.74138	11.916	1.489	.152
Education Index	.40129	1.713	.234	.817
Housing Index	-.52273	3.179	-.164	.871

MULTIPLE R^2 .6619

TABLE 8. RESIDUALS, PREDICTED AND OBSERVED FIRE DEATH RATES (EXPERIMENT 2)

GEOGRAPHIC AREA	RESIDUAL	PREDICTED RESPONSE	OBSERVED RESPONSE
Maine	5.3619	33.8381	39.2
Vermont	.8795	32.3205	33.2
New Hampshire	-6.1750	31.9750	25.8
Minnesota	1.4887	29.5113	31.0
North Dakota	-6.6659	35.6659	29.0
Montana	2.9468	30.2532	33.2
Idaho	-4.8619	28.3619	23.5
Washington	1.7276	27.8724	29.6
South Dakota	-9.6828	36.8828	27.2
Michigan	8.3369	24.5631	32.9
New York	.5352	30.4648	31.0
Wisconsin	3.8207	18.0793	21.9
Oregon	1.8423	30.3577	32.2
British Columbia	.1737	33.0263	33.2
Alberta	1.3456	35.3544	36.7
Saskatchewan	-10.8069	40.3069	29.5
Manitoba	-6.9335	36.1335	29.2
Ontario	.1565	31.8435	32.0
Quebec	2.6567	30.9433	33.6
New Brunswick	29.1084	42.7916	71.9
Nova Scotia	-6.1823	42.3823	36.2
Newfoundland	-1.3921	40.5921	39.2
Belgium	1.6425	11.2575	12.9
Denmark	-.9712	12.7712	11.8
Finland	3.4674	13.7326	17.2
West Germany	.1139	8.9861	9.1
Iceland	-2.3154	14.9154	12.6
Ireland	6.9385	14.9154	24.6
Netherlands	-7.7665	13.1665	5.4
Norway	-4.7507	19.7507	15.0
Sweden	3.7396	11.2604	15.0
United Kingdom	-7.7784	22.7784	15.0

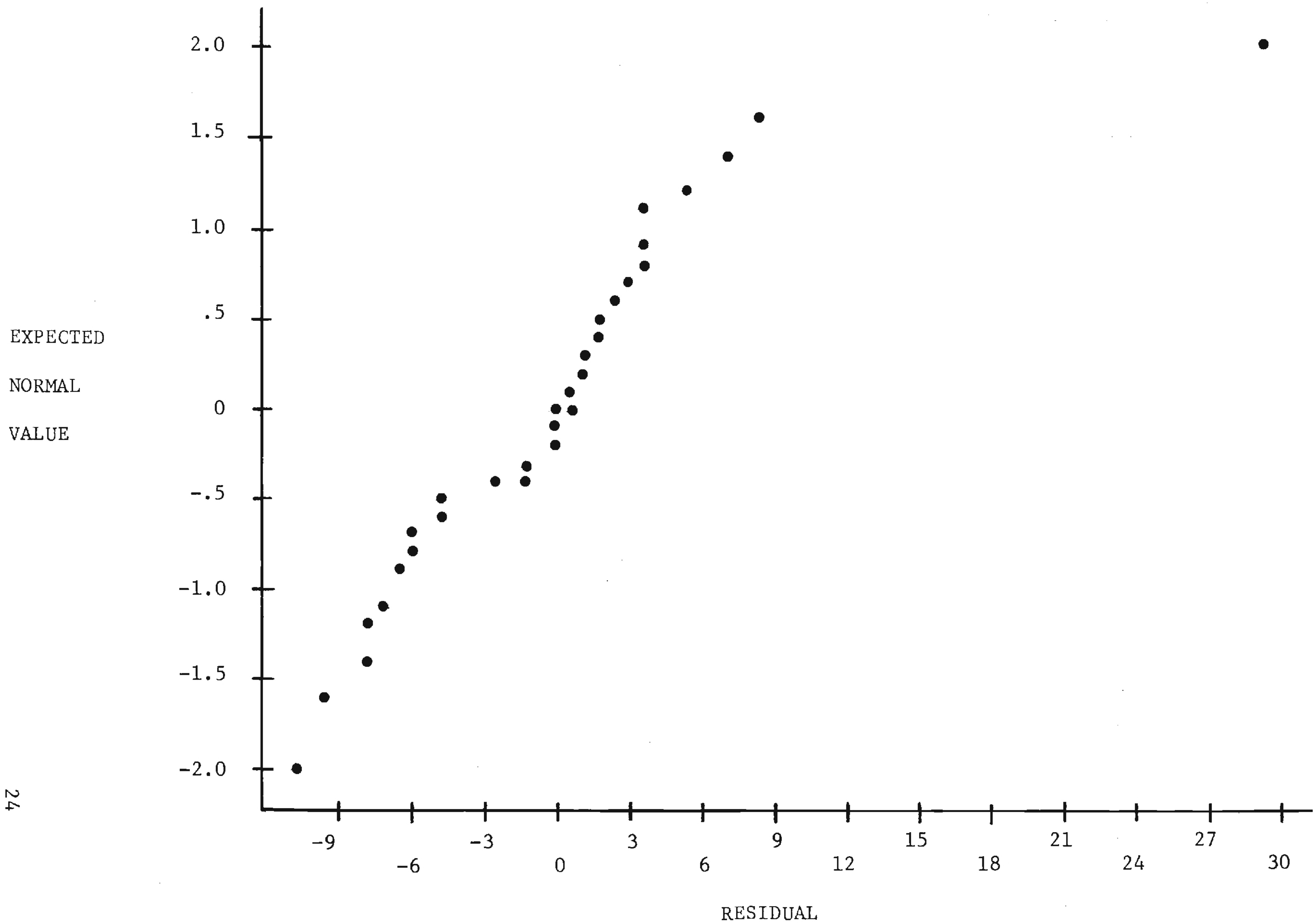

FIGURE 3. NORMAL PROBABILITY PLOT OF RESIDUALS (EXPERIMENT 2)

TABLE 9. INPUT DATA (EXPERIMENT 3)

VARIABLE	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION	MINIMUM	MAXIMUM
Fire Death Rate	33.97292	10.23055	.30114	16.8	65.2
Urban Population	65.84792	14.47332	.21980	32.2	90.9
White Population	86.34583	9.55510	.11066	63.6	99.0
Income	.99071	.12982	.13104	.717	1.262
Cigarette Consumption	1.27340	.26103	.20498	.701	2.33
Education Index	12.46250	.17580	.01411	12.1	12.8
Alcohol Consumption	2.85688	.90820	.31790	1.77	7.05
Housing Index	92.62083	5.21091	.05626	77.3	98.3
Open Flame Heating	.06250	.24462	3.91397	0	1
Technology Index	2.00004	.12682	.06341	1.736	2.206
Fire Fighters	1.70375	.27082	.15895	1.12	3.1
Fire Equipment	.11704	.01512	.12923	.083	.183

is of principal interest to see what effect this variable has on the response. However, because of their known significance, variables such as Cigarette Consumption, Alcohol Consumption and so forth must also be included in the model.

Table 10 presents the correlation matrix of each of these variables with the fire death rate. Notice that there are a number of very high correlations, including White Population (-.5363), Urban Population (-.5029), Income Index (-.6163), Education Index (-.6501), Housing Index (-.7897) and Techonology Index (-.4995). This indicates that potentially a very good regression model can be built explaining fire death rate as a function of these candidate regressors.

The basic regression results are summarized in Table 11. That the significance level for the regression is zero to five decimal places indicates that we have a very strong model. Notice that the R^2 is .7291. That is, about 73% of the variability in the fire death rate is explained by the candidate regressors chosen in this model. Examining the t statistics and the level of significance, it quickly emerges that White Population and Housing Index are major factors in explaining the fire death rate, because these variables are highly significant (at the .010 and .012 levels, respectively). Table 12 presents the residuals, predicted and observed responses from this model. In this table, the states are shown in alphabetical order excluding Alaska and Hawaii. Only one residual exceeds two standard deviations, implying that the model is an adequate fit to the data. (If the residuals are $N(0, \sigma^2)$, then only five percent of them should exceed $\pm 2\sigma$). This impression is confirmed by examining the normal probability plot of residuals, shown in Figure 4.

TABLE 10. CORRELATION MATRIX (EXPERIMENT 3)

	FIRE DEATH RATE	URBAN POPULATION	WHITE POPULATION	INCOME INDEX	CIGARETTE CONSUMPTION	EDUCATION INDEX	ALCOHOL CONSUMPTION	HOUSING INDEX	OPEN FLAME HEATING	TECHNOLOGY INDEX	FIRE FIGHTERS	FIRE EQUIPMENT
FIRE DEATH RATE	1.0000											
URBAN POPULATION	-.5029	1.0000										
WHITE POPULATION	-.5363	-.0916	1.0000									
INCOME INDEX	-.6163	.7139	.1684	1.0000								
CIGARETTE CONSUMPTION	.0513	.1863	.1859	.0305	1.0000							
EDUCATION INDEX	-.6501	.4600	.4692	.5503	-.2282	1.0000						
ALCOHOL CONSUMPTION	-.2798	.2440	.1723	.3848	.3454	.4342	1.0000					
HOUSING INDEX	-.7897	.6967	.4478	.7637	-.1184	.8300	.4073	1.0000				
OPEN FLAME HEATING	.1121	-.3494	.3374	-.2285	.4724	.1051	.3380	-.0244	1.0000			
TECHNOLOGY INDEX	-.4995	.5098	.2789	.7121	.1520	.3896	.2548	.6375	-.0851	1.0000		
FIRE FIGHTERS	.0502	.1762	.0266	.1490	-.1598	.1335	.0434	.1135	-.0422	.1283	1.0000	
FIRE EQUIPMENT	.0872	.1241	-.0184	.1667	-.1758	.2127	.0755	.0792	-.0180	.0619	.8761	1.0000

TABLE 11. REGRESSION SUMMARY STATISTICS (EXPERIMENT 3)

	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F RATIO	SIGNIFICANCE LEVEL
REGRESSION	3586.563	9	398.507	11.363	.00000
RESIDUAL	1332.562	38	35.070		

VARIABLE	REGRESSION COEFFICIENT	STANDARD ERROR	t STATISTIC	SIGNIFICANCE LEVEL
Intercept	159.30908			
Urban Population	-.03740	.118	-.316	.754
White Population	-.37238	.137	-2.720	.010
Income	-9.25380	14.165	-.653	.518
Cigarette Consumption	-1.15782	4.560	-.346	.731
Housing Index	-1.13961	.427	-2.648	.012
Open Flame Heating	8.39304	4.940	1.699	.098
Technology Index	6.76496	10.478	.646	.522
Fire Fighters	2.73522	6.979	.392	.697
Fire Equipment	54.40685	126.515	.430	.670

MULTIPLE R^2 .7291

TABLE 12. RESIDUALS, PREDICTED AND OBSERVED FIRE DEATH RATES (EXPERIMENT 3)

STATE	RESIDUAL	PREDICTED RESPONSE	OBSERVED RESPONSE
Alabama	-4.8029	48.8029	44.0
Arizona	2.3632	30.8368	33.2
Arkansas	.6600	52.9400	53.6
California	-4.8456	28.3456	23.5
Colorado	-7.7648	26.7648	19.0
Connecticut	-4.8264	24.7264	19.9
Delaware	-7.4846	30.8846	23.4
Florida	-5.7156	31.4156	25.7
Georgia	-1.1372	44.9372	43.8
Idaho	-10.3488	27.1488	16.8
Illinois	6.6569	30.6431	37.3
Indiana	-1.0247	29.4247	28.4
Iowa	2.3316	28.4684	30.8
Kansas	-5.2048	27.7048	22.5
Kentucky	-5.7393	43.5393	37.8
Louisiana	1.0161	42.8839	43.9
Maine	7.7140	44.9860	52.7
Maryland	.4846	38.7154	39.2
Massachusetts	2.1225	32.5775	34.7
Michigan	10.9273	24.7727	35.7
Minnesota	-.6216	28.2216	27.6
Mississippi	4.3627	60.8373	65.2
Missouri	-2.1277	33.8277	31.7
Montana	4.9882	30.7118	35.7
Nebraska	-.1779	28.0779	27.9
Nevada	2.1014	26.2986	28.4
New Hampshire	-5.1432	33.4432	28.3
New Jersey	-1.5128	27.3128	25.8
New Mexico	1.7810	38.9190	40.7
New York	-7.2925	28.9925	21.7
North Carolina	-2.9010	46.0010	43.1
North Dakota	-1.8453	34.1453	32.3
Ohio	-.9495	27.2495	26.3
Oklahoma	11.2618	31.9382	43.2
Oregon	12.3990	24.9010	37.3
Pennsylvania	4.9724	28.7276	33.7
Rhode Island	.2170	23.8830	24.1
South Carolina	2.4841	51.9159	54.4
South Dakota	-7.3039	36.6039	29.3
Tennessee	5.0793	43.4207	48.5
Texas	2.5808	33.7192	36.3
Utah	-.7659	24.6659	23.9
Vermont	-2.5708	36.6708	34.1
Virginia	-5.8176	40.3176	34.5
Washington	3.5189	27.5811	31.1
West Virginia	.8594	40.7406	41.6
Wisconsin	-2.6652	26.5652	23.9
Wyoming	9.7075	24.4925	34.2

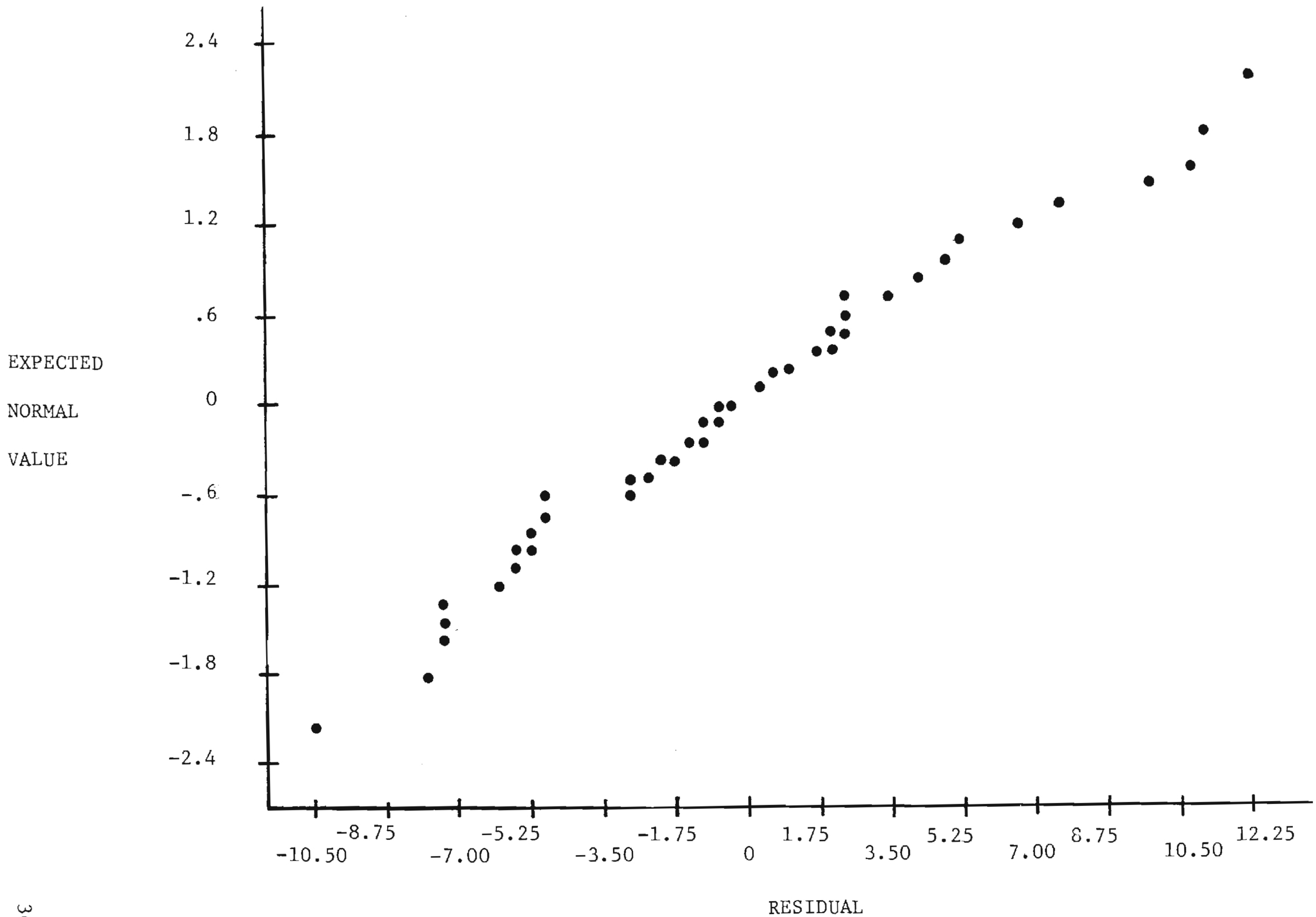

FIGURE 4. NORMAL PROBABILITY PLOT OF RESIDUALS (EXPERIMENT 2)

Residuals plot approximately along a straight line, indicating that the normality assumption on the errors inherent in linear regression is approximately satisfied. At this point, we have no strong evidence to doubt the adequacy of the model.

SIMILAR STUDIES

Similar studies have been conducted by other investigators, at the community, rather than international level. For example, Sunbelt Research [1] indicated a relationship between residential fire rates and percent minority (black) population at the .01 level of significance. The study area consisted of census tracts in Baton Rouge, Louisiana. Gunther [2] found that "race bears little relationship to overall fire rate, except insofar as the differences show up as differences in income." Gunther's study area was Toledo, Ohio and his concern was residential fire rates. Note that these studies were both confined to residential areas within population centers (rather than entire states or nations) and both dealt with rates of incidence (rather than the death rate). Hall and Karter [3], Karter and Donner [4] and Munson [5] have found that neighborhoods in the inner core of most large cities usually experience residential fire rates several times greater than other sections of the city. Socioeconomic variables were related to fire rates in each of these last three references.

CONCLUSION

Three natural experiments have been conducted in this research with a multiple linear regression model developed for each experiment. Each model has been subjected to rigorous analysis of variance, hypothesis tests, and residual analyses.

The results obtained are impressive. All the regression models presented are reasonably adequate descriptors of the data, and explain a significant proportion of the variability in fire deaths.

It is possible that a more complete and more up to date data base can be obtained. If more efforts can be devoted to refinement of the data base and regression model building, even greater strides can be made in determining the causal agents for fire losses.

REFERENCES

1. "Baton Rouge Fire Household Survey (Draft)," Sunbelt Research, Baton Rouge, February, 1979.

2. Gunther, Paul, "Fire-Cause Patterns for Different Socioeconomic Neighborhoods in Toledo, Ohio," Fire Journal, Vol. 75, No. 3, 1981.

3. Hall, John R. and Michael J. Karter, Jr., "Fire Rates vs. Community Characteristics," Supplemental Technical Report, Urban Institute, Washington, D.C., 1976.

4. Karter, Michael J. Jr. and Allen Donner, "The Effect of Demographics on Fire Rates," Fire Journal, Vol. 72, No. 1, 1978.

5. Munson, Michael J., "Residential Fires and Urban Neighborhoods: An Empirical Analysis of Charlotte, N.C.," Princeton University, 1977 (NTIS, PB-280697).